JUN 29 1950

498

March 14 Sun. **Daguerreotype of Jupiter**

4h 52m 10s 4..53..40
53..20

March 14th Pk Messrs Whipple & Jones continued the experiments in daguerreotyping the moon which they have recommenced on the 12th. Though much troubled by clouds & with an unsteady atmosphere - they made trial of 5 or 6 plates on the 12th & of 12 on the 14th

On the 12th the chief progress made was in ascertaining that the proper time for exposure was from 10s to 15s

On the 14th they decided on trying the effect of altering from the visual focus to find the photogenic focus.

The effect was at once apparent in the great improvement of the picture which is now obtained so as to give a better representation of the lunar surface than any engraving of it that I have ever seen.

The photogenic focus was decided to be about 1/2 an inch longer than the visual.

March 22nd Succeeded in Daguerreotyping Jupiter at about 11 Pk - took six plates more than 24h old. Could distinguish the two principal equatorial belts. Time taken as long as the moon required or not much longer.

LETTERS

Sir:

The teachers' committee of the American Astronomical Society is conducting a census of its own this spring. Charged with encouraging and supporting the teaching of astronomy, the committee found that it did not have a directory of colleges at which astronomy is taught, and found also that reliable information was lacking on current trends in the teaching of introductory astronomy. The committee also wished to learn what types of classroom and laboratory equipment are in demand, and what use can be made of motion pictures.

To provide the desired facts, questionnaires have been mailed to some 370 colleges which are known to offer courses including introductory astronomy in some form. Answers to the 44 questions will bring to the committee the information it needs to function most usefully.

The committee is most anxious to learn of every college at which introductory astronomy is taught, whether as a separate subject, in combination with other sciences, or under the auspices of physics, mathematics, or some other academic division. It is therefore urged that any reader of **Sky and Telescope** who teaches college astronomy, and whose department did not receive a questionnaire, should write to the undersigned at the University of Michigan Observatory, Ann Arbor, Mich., so that a copy may be sent to him.

FREEMAN D. MILLER, chairman
Teachers' Committee
American Astronomical Society

Sir:

A perennial problem of many amateur astronomers is the obtaining of a good map of the moon. The attentive lunar observer soon outgrows such small and very general charts as, for example, the one on page 31 of the 10th edition of Norton's **Star Atlas.** Before long, he learns of W. Goodacre's **Moon** and the detailed sectional map it contains; the only troubles are that he is not apt to get an opportunity to buy a rare book now out of print for years and that the price is likely to exceed his means even if the opportunity should arise.

This lack of an easily available and adequate map of the moon was beautifully remedied in 1946 when H. P. Wilkins, the lunar director of the British Astronomical Association, published his excellent and detailed map of the lunar surface. Drawn on a scale of 300 inches to the moon's diameter, it was published on a scale of 100 inches (one-third size). As with Goodacre's map, the moon is divided into 25 sections; a few small sections have been combined so that there are 22 separate charts. This map may be obtained from Mr. H. P. Wilkins, 35 Fairlawn Ave., Bexleyheath, Kent, England. The amount of detail shown **greatly** surpasses that on any other lunar map that I have ever seen. There are certainly enough hills, craterlets, clefts, mounds, and so on, to provide plenty of good hunting for lunar enthusiasts for many years.

For lunar students who like to have a map of the moon handy at the telescope while they observe, and many apparently do, the large size of the Wilkins map is inconvenient; each chart is 21 inches square. I was hence much interested when the Stevens Agency in Albuquerque proposed making a photographic copy of the map on a reduced scale. With Mr. Wilkins' kind permission, this suggestion was carried out. Each of the 22 charts of the original was photographed on a piece of stiff paper of good quality and about eight inches square. This size is very handy for use at the telescope; and the set of charts can easily be bound in a notebook, if desired. The quality of the photographic copying has been pronounced excellent by persons qualified to judge; the finest details are shown well. These charts are sold by the Stevens Agency, 202 S. Broadway, Albuquerque, N.M., for $12.00 per set; for $2.00 more they will furnish transparent jackets protecting the charts against dirt and dew.

The Association of Lunar and Planetary Observers, of which the writer is director, is making these same charts available to its members as a special service. They will be reproduced serially in the association's monthly publication, **The Strolling Astronomer**, one chart per issue. It is tentatively planned to begin publishing them in the October, 1950, issue.

Both Mr. Wilkins and I hope that the wider distribution of his map may lead to an increase of interest in the moon. Even an excellent 6-inch telescope in skilled hands can do good work in charting more accurately many portions of the lunar surface. If some readers of **Sky and Telescope** are stimulated to obtain the Wilkins map in any of the three editions described and then to study the moon with its help, this note will have achieved its purpose.

WALTER H. HAAS
Institute of Meteoritics
University of New Mexico
Albuquerque, N.M.

Sky and TELESCOPE

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BACK COVER: The region of the Milky Way centered near Theta Ophiuchi, photographed by Frank E. Ross, at Flagstaff, Ariz., May 24, 1931, exposure $3^h\ 20^m$ with a 5-inch f/7 Ross lens. From Plate 3 of the **Atlas of the Northern Milky Way,** by Frank E. Ross and Mary R. Calvert. (See page 212.)

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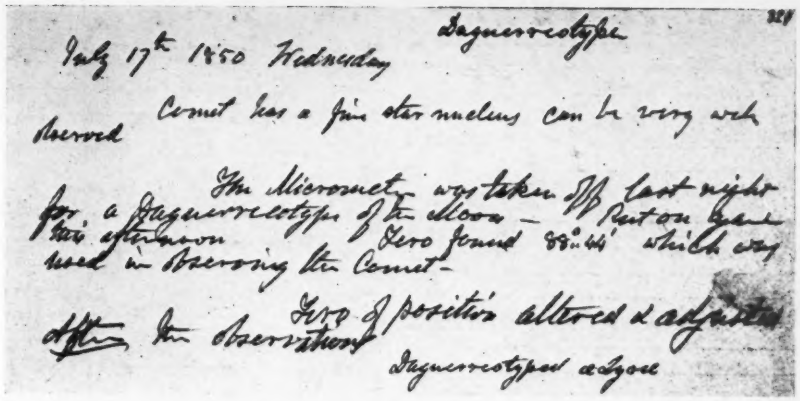


From the record book of the Great Refractor, this is the record of the first star photograph, a daguerreotype of Vega. The topmost word and the lowest line are in ink, indicating that they were added after the remainder of the record, in pencil, had been made.

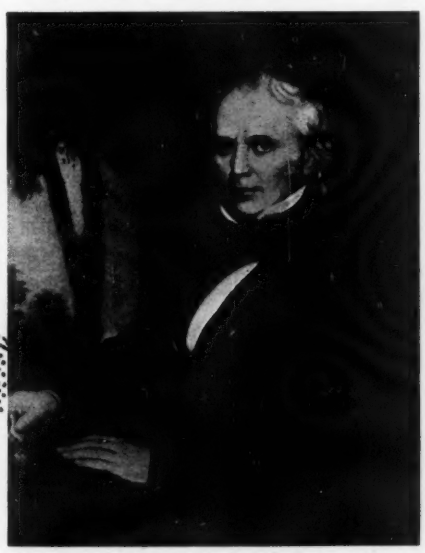
The First Star Photograph

By Dorrit Hoffleit
Harvard College Observatory

JUST ONE HUNDRED years ago, on July 16-17, 1850, J. A. Whipple, working under the direction of William Cranch Bond, was carrying out an experiment with the great 15-inch refractor at Harvard College Observatory. The result of that experiment was the first daguerreotype picture of a star—Vega. It required an exposure time of 100 seconds. In these earliest Harvard attempts at stellar photography, 1st-magnitude stars needed exposures of a minute or two, while 2nd-magnitude stars would not "take" at all. Moreover, not all the plates showed round images, the Munich drive of the telescope being unable to follow a star exactly.

Yet seven years later, in a letter to William Mitchell, George P. Bond wrote enthusiastically that these early simple tests, having established "the possibility of such an achievement," what could not a telescope of threefold aperture on some lofty mountain and in a purer atmosphere do!

"We should be able then to photograph all the stars to the tenth and eleventh magnitude inclusive. There is nothing, then, so extravagant in predicting a future application of photography to stellar Astronomy on a most magnificent scale.... What more admirable method can be imagined for the study of the orbits of the fixed stars and for resolving the problem of their annual parallax than this would be, if we could obtain the impressions of the telescopic stars to the tenth magnitude? Consider, too, that groups of ten, or fifty even, if so many occur in the compass of the field, will be taken as quickly as one alone would be—perhaps in a few seconds only—and each mapped out with unimpeachable accuracy .... The intensity and size of the images, taken in connection with the length of time during which the plate has been exposed, measures the relative magnitudes of the stars.... The measurements of distances and angles of position of the double stars from the plates we have ascertained, by many trials on our earliest impressions, to be as exact as the best micrometric work."



William Cranch Bond, director at Harvard when the first daguerreotype of a star was taken, July 16-17, 1850.

At the time this letter was written, other observatories than Harvard had not begun photography of the stars. Nor had the attempts at Harvard been very numerous. Nevertheless, the younger Bond thus accurately visualized the revolutionizing effect that photography would have upon the subsequent progress of astronomy. His predictions, however, were not to be realized within his own lifetime. Not until the perfection of the dry plate some 20 years later did Bond's vision begin to reach fulfillment. On the other hand, the achievement under William Cranch Bond in 1850 was the climax of several centuries of experimentation that may be considered as having begun with Leonardo da Vinci and the idea of the camera obscura in the 15th century.

As for the daguerreotyping at Harvard, from the annual reports of the director of the observatory one gathers that the first attempts at photography here were made some time in the year 1848. In the report for that year, W. C. Bond wrote:

"The physical condition of the sun's disc has been attended to whenever the state of the atmosphere has admitted of distinct delineation. Some experiments made with the Daguerreotype and Talbotype processes, for the purpose of obtaining impressions from the image formed by the telescope, have not been attended with complete success. The application of these processes to astronomical purposes is met by a serious difficulty in the variable refraction of the atmosphere. However, we do not despair of ultimate success, when our time and means are adequate to the requisite expenditure."

The next mention of photographic work in the annual reports occurs in the one for the year 1850, which states:

"The smaller equatorial has occasionally been used for Daguerreotype experiments; and it will answer a most valuable purpose when placed, as it is intended, in the dome of the new building, where, in connection with the comet-searcher, and the requisite apparatus for photographic operations, it can be used more efficiently than in its present situation."

Later this same account marks the official beginning of stellar photography, with the 15-inch refractor:

"With the assistance of Mr. Whipple, daguerreotypist, we have obtained several impressions of the star Vega (α Lyrae). We have reason to believe this to be the first successful experiment of the kind ever made, either in this country or abroad. From the facility with which these were executed, with the aid of our great equatorial, we were encouraged to hope that the way is opening for further progress. If it should prove successful when applied to stars of less brilliancy than α Lyrae, so as to give us correct pictures of double and multiple stars, the advantages would be incalculable."

The original record books used by the Bonds while they were observing at the great 15-inch refractor 100 years ago are still kept in the same building in

which the telescope stands. In perusing these old books for their occasional notes on daguerreotyping or photography (the latter term seems to have been reserved for the collodion process), one cannot help but be impressed by their striking conservatism in contrast to the expression of confidence displayed in the annual reports, quoted above, and the relative "glamorousness" of newspaper accounts of the same experiments appearing but a very short time after the experiments themselves.

Ever since the earliest observations made at Harvard Observatory, it had been the rule that original observations made at the telescope be recorded in pencil. Anything added later, from memory, or by way of comment, or reductions of the observations, should be added in ink only. In the early records made by the Bonds at the 15-inch refractor most of the notes are extremely brief, but revealing. Inside the front cover of the notebook covering the period from December, 1849, to April, 1850, is the notation (in ink), *"Daguerreotyping with Great Refractor Commenced Dec* 18th, 1849. *See date."* On the page for the date in question we find:

Daguerreotyping

NOTE On the evening of the 18th just as we were commencing observations on Mars, Messrs Whipple and Jones came to take a Daguerreotype of the Moon. And very much against our inclinations we unscrewed the Micrometer (for the first time for more than a year past I should judge) The zero of position was afterwards reduced to nearly 180° but from several obs. I concluded it was about 179° 53′ But for all the foregoing obs. the zero used was 0° and 180°

I suppose—i.e. for all obs on Dec 18th taken after daguerreotyping.

The success of this interruption of the regular work of the observatory is apparently nowhere commented upon. Three days later the records suggest there was still a bit of unhappiness that the micrometer should have been disturbed:

Dec 21st 22^h Sid Adjustment of Position Circle

θ Aquarii Zero before adjustment 269° 58′ but not thought to be firmly screwed home.

From the record books we gather that the daguerreotypists did not again invade the dome for nearly seven months. Then we find:

Daguerreotype

July 17th 1850 Wednesday

Comet has a fine star nucleus can be very well observed

The Micrometer was taken off last night for a Daguerreotype of the Moon — Put on again this afternoon Zero found 88° 44′ which was used in observing the Comet —

Zero of position altered and adjusted *After* the observations

Daguerreotyped α Lyrae

Evidently, then, the memorable first portrait of a star (other than the sun) was obtained on the night of July 16-17,

A photographic reproduction of one of the best daguerreotypes of the moon extant in the Harvard collection, taken February 26, 1852, with the 15-inch.

not on July 17 as G. P. Bond and others since have quoted. Moreover, the fact that α Lyrae had been photographed at all was entered into the notebook only sometime after the night of the 17th, as it is a notation in ink. Either the observers were too excited to remember to make a record at once, or else the astronomers were too nettled with the interruption and the necessity for tampering with the micrometer to bother to record an experiment which might conceivably have been unrewarding. As late as October 15, 1850, we find a comment on the adjustment of the position circle on the micrometer, which had needed a 12-minute zero correction "since the date when the Micrometer was removed for Daguerreotyping."

The public, however, was accorded a much happier account, judging from a newspaper clipping found in a scrapbook kept by the Bonds. The clipping is undated and the name of the newspaper is not given; but from neighboring items it is readily apparent that it refers to the achievement of the night of July 16, 1850. The entire clipping reads:

DAGUERREOTYPING STARS.—It was recently announced that Mr Bond of the Cambridge Observatory, had succeeded in taking a daguerreotype of the star Lyrae, which is not [sic] visible to the naked eye. An interesting communication in relation to this subject from Mr Bond, is published in the Boston Advertiser, from which we make the following extract:

"The question will doubtless occur to many of the readers of that article, to what good purpose can this discovery be applied? One of the first direct applications of it would be the measurement of the angles of position and distance of double stars. It is interesting to be assured of the fact that the light emanating from the stars possesses the requisite chemical properties to produce effects similar to certain of the solar rays, and that these properties retain their efficacy after traversing the vast difference which separates us from the stellar regions. Of this distance some idea may possibly be formed, if we can imagine a plain of two hundred millions of miles in extent, at the distance of the star alpha Lyrae, and favorably presented to a spectator situated on the earth, appearing as a mere point, only measurable by the aid of an excellent telescope, furnished with an accurate micrometer; or that light moving at the rate of 190,000 miles in a second of time would require more than twenty years to traverse the intervening space. Yet such are the facts, and it follows that the ray of light which made the first impression, on our daguerreotype plate on Tuesday evening [July 16, 1850, was a Tuesday], took its departure from the star more than twenty years ago; long before Daguerre had conceived his admirable invention.

Our experiment have also a bearing upon the nature of the light emitted from the stars.

The images which we have thus far obtained, are quite decided, having pretty distinct nuclei, although elongated, and to broad for the nices purpose of measurement. This apparent enlargement of the disc we attribute, in a great measure to two causes. One is the variable nature of the atmospheric refraction, when influenced by sudden changes of temperature. This trouble we hope to get rid of by increasing the sensitiveness of the surface receiving the impressions. The other operation will then require less time and of consequence, be subject to fewer and less extensive vibrations.

The other difficulty to be overcome is the irregular motion of the machinery which carries the telescope. Although the machinery at present attached to the telescope is the best that German ingenuity could devise, and answers a tolerable good purpose on ordinary occasions, yet it is deficient for our nices operations. The telescope should during the process, be propelled with a uniform sideral motion, in order that the successive rays from the star may fall on precisely the same part of the plate which is to receive the impression. If this be not the case, the image will be deficient in the distinctness of outline and unduly enlarged.

To effect this, we intend to apply to our great equatorial, a machine which we have devised for the purpose of producing uniform rotary motion, one of which machines is now constructing at the observatory, to be used in connection with the electrographic operations of the Coast Survey.

It is our purpose to pursue the subject of daguerreotyping the stars, proceeding step by step from the brighter to those of lesser magnitude. We do not despair of obtaining ultimately, faithful pictures of clusters of stars and even nebulae.

In spite of these exuberant prospects, the next mention of daguerreotypes made at the 15-inch telescope is not before March 14, 1851. This record, however, occupying two thirds of a page in the observing book, is both more informative and, one feels, more enthusiastic than earlier notes (see the front cover):

March 14th PM Messrs. Whipple and Jones

continued the experiments in daguerreotyping the Moon which they had recommenced on the 12th Though much troubled by clouds and with an unsteady atmosphere — they made trial of 5 or 6 plates on the 12th and of 13 on the 14th

On the 12th the chief progress made was in ascertaining that the proper *time* for exposure was from 10ˢ to 15ˢ

On the 14th they decided on trying the effect of altering from the visual focus — to find the photogenic focus

The effect was at once apparent in the great improvement of the picture which is now obtained so as to give a better representation of the Lunar surface than any engraving of it, that I have ever seen

The photogenic focus was decided to be about ½ an inch longer than the visual

March 14, 1851, is thus evidently the first date on which it was actually demonstrated that the effective photographic focus differs from the visual. But the correct focus was approached with caution; subsequent notes show that the best photographic focus had not yet been reached. Except for an entry on the 22nd of March, and an irregular note jotted inside the cover of the notebook stating that seven daguerreotypes of the moon had been taken on September 6th, no further daguerreotyping at the 15-inch is then recorded until late in February of 1852. At that time the "chemical focus" was found to be 1⅛ inches longer than the visual, and later work, in 1857, indicated between 1¼ and 1½ inches.

The record on March 22, 1851, also reveals a new discovery:

Succeeded in Daguerreotyping Jupiter at about 11 PM — took six plates more than 24ʰ old —

Could distinguish the two principal equatorial belts — Time about as long as the Moon required or not much longer.

This at first perhaps surprising note on the approximately equal exposure times required for photographing the moon and Jupiter is also of historic interest. Although the total light from the moon is considerably greater than that of Jupiter (because of the tremendous difference in angular diameter) the apparent surface brightness of Jupiter appears visually greater. Nearly seven years after this obscure but significant Harvard observation, De la Rue (*Monthly Notices, 18,* 54, 1858) rediscovered this near-equality of the *photographic* surface brightnesses of Jupiter and the moon. His comments may well be considered as the first discussion of the color index of a heavenly body.

One of the earliest double star photographs, showing two images of the components of Mizar separated by about 14.6 seconds of arc. It was made by the wet-plate process on May 8, 1857, with Harvard's 15-inch refractor.

A collodion process photograph of Spica and the moon shortly after the star had emerged from occultation June 2, 1857. Spica's image is at bottom of the picture, which is here enlarged to about 1½ times original size. W. C. Bond reported having the assistance of Whipple and Black, and a large number of pictures were taken before and after the occultation; "even at the emersion, when the star was in apparent contact with the bright limb of the moon, its image was distinctly formed."

Meanwhile, the Harvard successes in daguerreotyping celestial bodies had won prestige for the Bonds and the observatory. In his report for 1851, W. C. Bond noted that Whipple had taken improved daguerreotypes of the moon and several of the stars. Some of these excited the admiration of eminent men in Europe, to whom G. P. Bond presented specimens. "For these Mr. Whipple has been awarded a prize medal at the great exhibition in Hyde Park."

From February 26 through March 3, 1852, Whipple took more than a dozen plates of the moon.* Several notes recorded at about that time indicate the progress in scientific thinking. It was found that images of the full moon required five seconds, while a crescent moon took 20 or 30. The observers wondered, "Whether it is that the (*straight?*) edge of the moon is less strongly illuminated or whether there is some sympathy in the action over the whole plate which makes it possible to take a picture quicker when the whole of it is exposed to a strong light than when only a small part of its surface is." They also found that "when the night is ever so slightly hazy the time must be prolonged two or three times."

W. C. Bond's annual report for 1852 was less encouraging than that of the previous year:

"In February, March, and April some new trials were made in daguerreotyping the moon and some of the fixed stars and clusters; but, without more powerful and accurate machinery for driving the telescope of the large equatorial, there is little prospect of improvement upon the impressions heretofore obtained, unless, by some increased susceptibility of the plates, a shorter time may be required for obtaining an impression. The shortest successful exposure of a plate has hitherto been from five to six seconds."

Thereafter, the record books kept at the 15-inch made no further reference to photography until January, 1857, when Whipple and Black again took up lunar photography, making their first attempt with the wet-plate collodion process on April 3rd. During April and May there were many experiments, for example, on April 4th:

Photography 8ʰ to 9ʰ PM Atmosphere hazy with cirrus — Collodion process took about 13ˢ. Got some improved pictures at primary focus of object glass — Clock motion adjusted this morning by R. F. B. and is very exact — being now regulated to the Moons motion — The Photographs obtained on the evenings of the 3 and 4th were improvements on those formerly taken. Neither of the evenings were favourable.

On April 25th, they took photographs of Castor, obtaining elongated images;

*On the latter date we find the memorandum, "Paid $65 to Mr. W. for compensation in last years daguerreotyping." Presumably this was for materials since Whipple volunteered his services.

on the 27th, however, stellar photography had begun with real enthusiasm:

Fine night very clear and good definition — Took by collodion process — (gun cotton in ether) several photographs of the Moon which was too low say about 25°? — Best one at 8h 13m m.s.t. when sky was very clear and limb steady — but time of exposure was 1m 20s!! The most important success of the evening was in obtaining a fine impression from Mizar 3rd and its companion (4th?) 5th magnitude, and a more distinct star of 5th mag. (Alcor) of the companion a very perfect and distinct image was taken — Of Alcor there was some doubt owing to spots on the glass plate which might be confounded with it but a daylight examination will test this. Mizar and its companion distant 14″ were beautifully distinct. Time of exposure 1m 20s about but no short time was tried and possibly a much shorter exposure would have answered as it was the shortest was the best — The altitude must have been above 70° The clock had only been approximately changed from lunar to sidereal motion — G. P. B.

After this success with the collodion process there are no further references to daguerreotyping until 1860. On February 7, 1860, a series of alternate photographs and daguerreotypes of the moon showed that the exposures for the daguerreotypes needed to be more than twice as long as for the collodion process. The last mention of daguerreotyping at the 15-inch was on May 4, 1860, when a series of exposures on Venus was taken; but it aroused no further interest.

During the 10 years that the Bonds conducted photographic experiments at Harvard, they obtained some 70 daguerreotypes and between 200 and 300 wet collodion plates on the moon, stars, and planets. But, although the collodion process had proved its superiority, it, too, was apparently abandoned (at least at the 15-inch) after the summer of 1860. Not until dry plates came into use was celestial photography actively resumed at Harvard, when in the 1880's W. H. Pickering's inspiration and E. C. Pickering's foresight and administration started the world's largest library of celestial photographs.

HARVARD CELEBRATION

A symposium on the "Futures of Photography" will be held at Harvard Observatory on the afternoon of July 17, 1950, with papers by Dr. Leo Goldberg, University of Michigan Observatory; Edwin H. Land, Polaroid Corporation; Dr. R. M. Scott, Perk'n-Elmer Corporation; and William F. Swann, Eastman Kodak Company. That evening, Dr. C. E. Kenneth Mees, of Eastman Kodak, will give a public lecture on photography. Attempts at daguerreotyping Vega will take place in the dome of the 15-inch refractor.

An exhibit of early photographic equipment and pictures will be held in the Fogg Museum at Harvard University, July 10th to 21st, sponsored jointly by the Fogg Museum and Harvard Observatory. The exhibit will be directed by Beaumont Newhall, curator of George Eastman House, Rochester, N. Y., who is providing much of the exhibit material.

TERMINOLOGY TALKS

J. Hugh Pruett

A CELESTIAL PROJECTILE so intensely dazzling that its fiery downward plunge through our atmosphere is easily visible in bright sunlight and from distances of 200 miles is rare, but not unknown. In the writer's 18 years of fireball tracing as Pacific regional director for the American Meteor Society, only two fireballs of the 29 worked up have appeared while the sun was high. The first was the noisy Portland meteor of July 2, 1939, which startled residents of the Oregon metropolis and environs and made news around the world within 24 hours. The other was the hunters' meteor of 2:32 p.m. PST, October 1, 1949.

Meteor Tracing

Meteor tracing is the general term that describes methods for determining the path of a meteor in the earth's atmosphere, usually by triangulation from observations at two or more points on the surface separated by 20 miles or more. When the motion of the earth and the effect of gravity are taken into consideration, the actual path of the meteor as a member of the solar system before its encounter with the earth may be obtained. Needless to say, such information is vital to our understanding of meteors and of the swarms of meteors that produce meteor showers.

Today, meteor tracing by visual means has been superseded in large measure by photographic and radar methods, and articles on such work have appeared in *Sky and Telescope* in the recent past.* Such methods, employed chiefly by professional astronomers and radar technicians at relatively few locations throughout the world, are of no avail when a brilliant fireball flashes across the sky, completely unheralded, observed unexpectedly by thousands of people who are not otherwise interested in or informed about astronomy. It is then that reports of visual observations furnish the only clues to the meteor's path and form the basis for a search for possible meteorites.

Fireball Reports

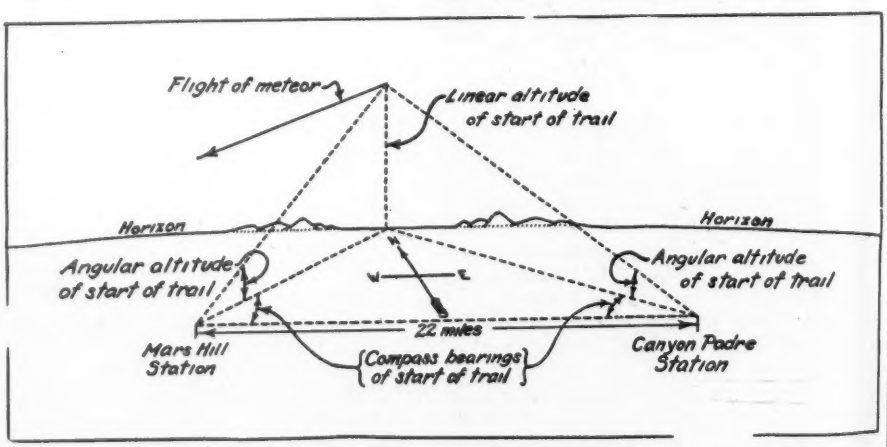
It is customary when a brilliant fireball appears over the Pacific states to ask at once through the news services that observers send reports to the American Meteor Society regional headquarters (to the writer at the University of Oregon, Eugene, Ore.). We usually receive about 100 letters on an average nighttime meteor. The twilight meteor over California and Nevada on November 29, 1945, brought 517. Had the hunters' meteor appeared at night, it should have been good for fully 150 reports; as it was, we received 47.

To many of those reporting we send questionnaires, either AMS Bulletin 16 or the simpler "Pacific edition" on which altitudes and azimuths can be indicated simply by marking diagrams of the kind shown here. We often send out cheap compasses for measuring directions and simple clinometers for altitudes. In some cases these are mailed to high school principals or instructors with the request that they help the observers measure angles. From tests once made on 50 persons, we found that 95 per cent estimate angular altitudes too high, most of them far too high, hence the need for clinometers.

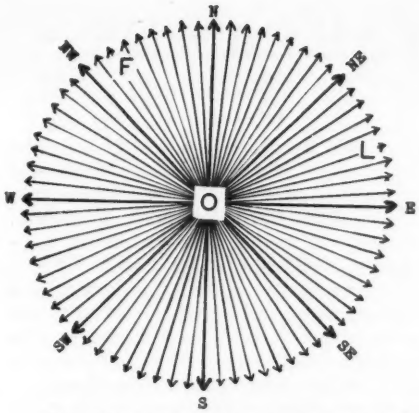
Beginning and End Points

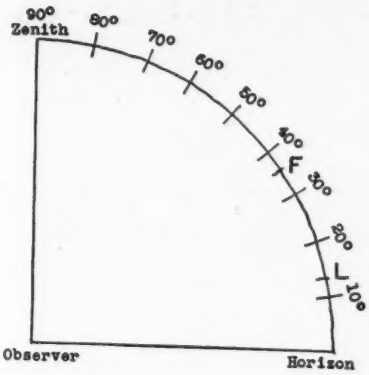
When the questionnaires start coming back, we are ready to begin plotting lines of sight on a large, carefully pre-

* "The Harvard Photographic Meteor Program," Fred L. Whipple, Vol. VIII, No. 4, February, 1949, and "Three-Station Radar and Visual Triangulation of Meteors," Peter M. Millman and D. W. R. McKinley, Vol. VIII, No. 5, March, 1949.



The manner in which simultaneous observations from two stations furnish data for triangulation on the beginning point of a meteor's luminous trail.





The charts supplied by the Pacific regional director of the American Meteor Society to facilitate reporting of fireball observations.

pared map. We run a dotted arrow from the observation point in the direction the meteor was reported "first seen"; a dashed arrow, in the direction of "disappearance." The convergence of the two sets of arrows indicates in general the "sub-beginning" and "sub-end" localities, the places over which the luminous phenomenon started and ended. Of course, not all observers thus reporting may have seen the actual *beginning* and *end points* of the meteor, but the accurate convergence of several lines of sight is generally indicative that the observers involved have done so.

Air and Ground Paths

A line connecting the plotted sub-beginning and sub-end points is the *ground path* of the meteor — observers situated along this line should have seen the meteor pass overhead in a direction perpendicular to the horizon. The ground path is usually indicated by a heavy arrow. The actual *air path* of the meteor requires observations of the heights of the beginning and end points. This is where the clinometer is used to check an observation for an exact value of the angular altitude. Once we know the distance, d, an observer is from the sub-beginning point, we get the approximate height, h, of the beginning point by the relation: $h = d \tan a$, where a is the angular altitude.

If the distance is considerable, we must add another term, $d^2/2R$, to account for the curvature of the earth, where R is the radius of the earth. From this term it may easily be calculated that the surface curves eight inches in one mile, and one mile in 89 miles. Of course, the formula fails for extreme distances, but it is satisfactory for those to which meteors can be seen.

The heights at the ends of the air path are not always very certain. Results calculated from data of various observers differ considerably, but the answers tend to cluster around certain reasonable values. Where uncertainty is considerable, many meteor tracers specially interview key observers whose data otherwise fit well.

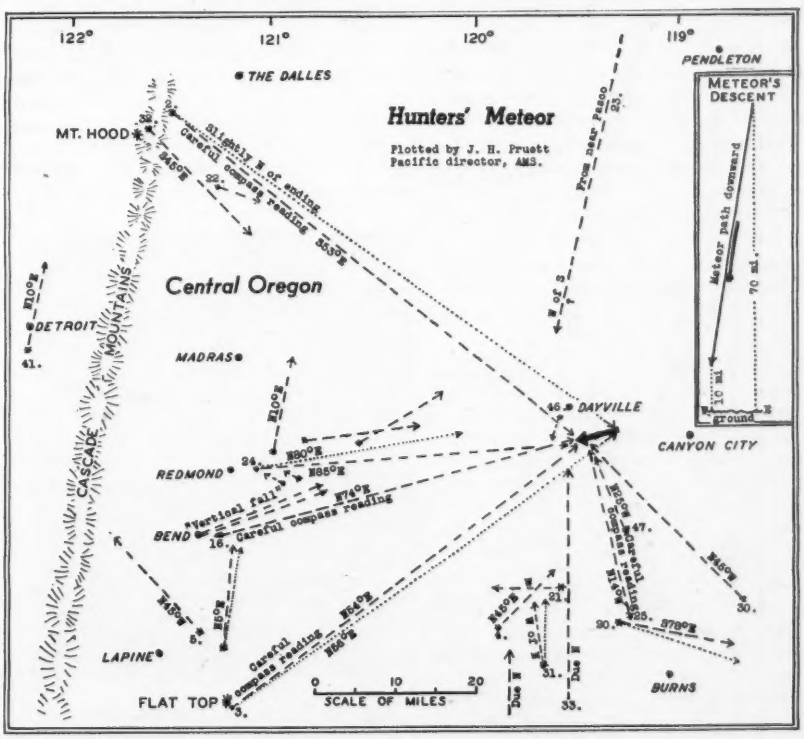
Hunters' Meteor Data

Last October the hunters' meteor was unique in more ways than brilliance. Coming down over a sparsely inhabited mountainous region of eastern Oregon, it would doubtless have been poorly reported had not hundreds of persons been afield for the opening day of the deer season. The great majority of the reports came from hunters. This fireball plunged earthward at an extremely steep angle. Observers from all sides wrote, "It seemed to come almost straight down." The duration of the luminous stage was very short, only one or two seconds according to numerous reports.

Most pleasing to the meteor tracer was the fact that four careful compass readings on the disappearance locality were made from widely separated places by highly intelligent people. Three of these came from hunting parties who had their compasses with them and took readings on the spot. The other was from the wife of Phil F. Brogan, of Bend, the Oregon assistant director of the AMS. She was sitting in a parked car and saw the fireball "come down into that juniper tree." Later the setting was re-enacted and the direction, north 74° east, was determined with a compass.

The noise of this meteor was intense, causing a seeming vibration of the ground as far as 40 miles from the object's sub-end point. "Sounded like thunder." "Shook the ground." "We thought the Hanford atomic works had blown up." "Made a screaming sound." "Great noise like a heavy explosion followed by rumbling resembling rolling rocks."

The height of appearance of the hunters' meteor was calculated as about 70 miles, that of disappearance not more than 10 miles and likely less. Many of the lines of sight run in wild directions. They were furnished by hunters without compasses and in unfamiliar locations. These "erratics" led a newspaper man to remark, "From the shots some of those hunters took at the fireball, it is quite evident why they did not bring home the venison."



The dotted lines show the reported direction in which the meteor was "first seen," dashed lines show direction in which "last seen." The heavy arrow is the estimated ground path.

TOURING SUMMER STARLANDS

By Leland S. Copeland

OUTSTANDING against the summer sky is splendid Scorpius, with big red Antares in its thorax. Farther west dimly shines the trapezium Libra, called the Claws by ancient Greeks. And above the Scorpion towers Ophiuchus, holding the long, curving Serpent. These stellar regions, like Arizona, have special appeal for summer vacationists, even though, like Arizona, their wonders are separated widely.

If we were touring that southwestern state, we could drive from torrid Needles northeastward through lava lands near Kingman, suggestive of moonscapes; visit that great book of geologic story, the Grand Canyon; roll southward to Mars Hill, where Pluto was discovered; and continue eastward to Meteor Crater and the Petrified Forest.

As we observe deep-sky wonders in Scorpius and Ophiuchus, we may be disappointed at first, like some visitors at Grand Canyon. That vast terrestrial marvel looks small through a quarter-inch aperture, the pupil of the human eye. A high school girl commented, "Pretty, isn't it?" A practical-minded plumber took only one look. "Just a big ditch," he muttered.

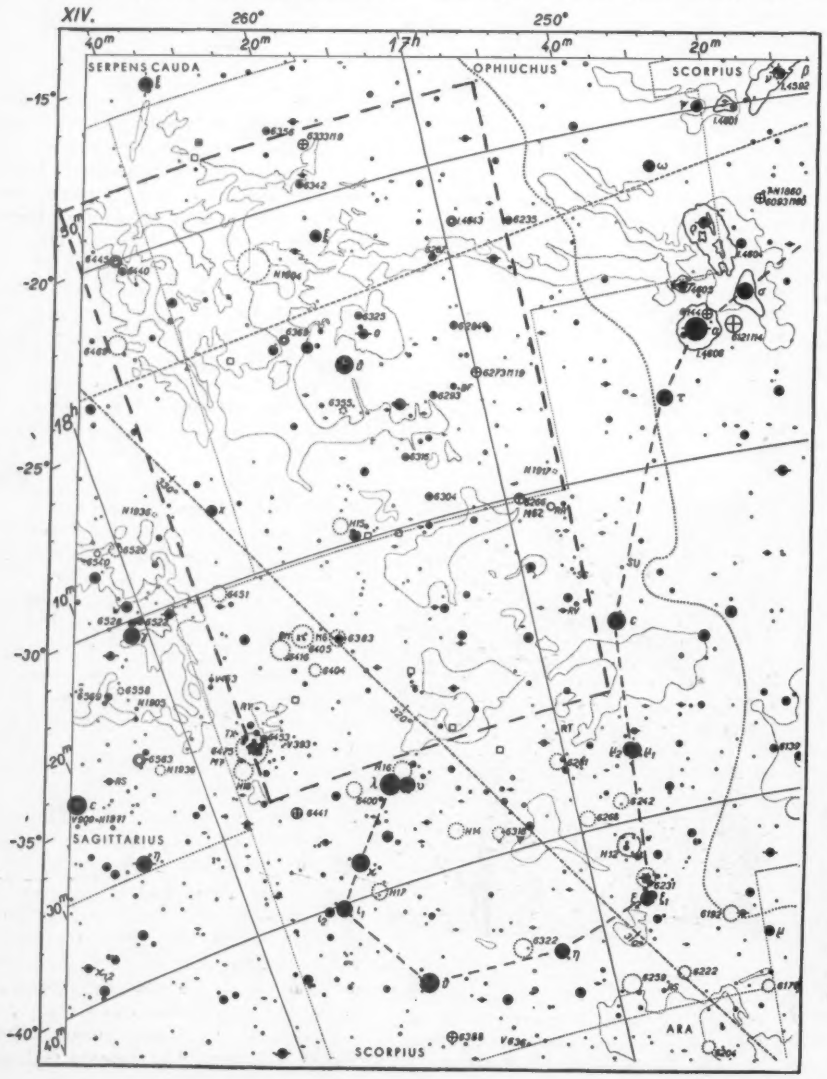
Similarly, as we look through amateur telescopes at summer starlands, everything is diminished disenchantingly. Even a bright professional photograph must be examined with appreciation. But to understanding minds the night sky suggests remarkable ideas, varying with the observer.

"When I consider Thy heavens, the work of Thy fingers," sings the Psalmist, "the moon and the stars, what is man?" But Lucretius, 50 years before Christ, painted a colder picture: "Nature, the universal mother, has done all by the might of immeasurable age. The cosmos was not divinely made, because defective. And who is able to rule boundless vastness, everywhere and always."

Among modern men, Sir James Jeans is speaking: "Incredible that the universe can have been designed for us. It appears hostile to life. Life seems to be utterly unimportant. To all appearances physics plays an incomparably greater part than biology."

Let us hear also from one who, while she was a home missionary, underwent a mind-shaking experience.

"On a sunny morning I was lying on fallen leaves under a hillside oak. My thought focused upon the sun; then wandered to the two planets nearer to it than the earth; next to those successively farther away. Suddenly came a sensation of being out in space, of being able to comprehend the magnitude of the planets and the distances between



Portions of Scorpius and Ophiuchus, as they appear on Plate XIV of the Skalnate Pleso "Atlas of the Heavens." The principal stars in Scorpius have been joined by a dashed line, and the area within the dashed "rectangle" is approximately that of the back-cover photograph. The star Theta Ophiuchi is 4½ inches from the left edge and a shy 4¼ inches from the top of the back cover. The "S" dark nebula is a short distance above it and is also shown in outline on this chart.

It is possible to make a detailed comparison of the outlines of the obscuring clouds in the Milky Way on the chart and on the back-cover photograph. On the chart, for instance, a long straight streak extending north and south almost to Theta Ophiuchi is marked, and easily seen on the back cover. Globular cluster M62 is four inches from the bottom and 1-1/8 inches from the right edge of the back cover; M19 is 6½ inches from the bottom and 1¼ inches from the right edge. Globular M9 is at the top edge of the picture, perhaps partially cut off depending on the loss in the bleed of the engraving.

A dozen globulars in all may be identified in this field, most of them looking like imperfect star images. There are some half a dozen open or galactic clusters, most of them in the vicinity of M6, the prominent cluster in the lower left, two inches from the left edge and 2½ inches from the bottom.

This chart shows the locations of many other objects mentioned in this article, such as NGC 6242, H12, and NGC 6231 between μ and ζ Scorpii.

them. I seemed to say, 'And beyond you, Neptune, what?'

"Almost immediately I emerged as from a dim gray atmosphere into bright sunshine again. Sitting up, I saw the towers of the nearby town, infinitesimally small, mere toys of man's invention. That experience caused me to discard certain doctrines taught by me and to write a new creed for myself."

Here we meet reactions to the mysteries of star-strewn space. In a free and tolerant world everyone may believe as he will and can, even those who accept astrological absurdities.

But back to nature, and first, looking photographically, let us take an overview of the shining fields across which we shall go sightseeing. The stellar summerlands of Libra, Serpens, Ophiuchus, and Scorpius, lie in or near the Milky Way, which fills the southeastern corner of the great region formed by these constellations.

Our Milky Way, seen at its radiant best in summer, is displayed here in three layers, like a gigantic sandwich. The meat is a serpentine blackness, the Great Rift, which runs from the head of the Northern Cross to the tail of Scorpius, then over our horizon nearly to the Southern Cross.

In wide-field photographs we see in Ophiuchus and Scorpius a seemingly chaotic wonderland, masses of white dots intermingled with black lanes and pockets. Also, we discover that the Great Rift is crossed by starry bridges or steppingstones, and that though the starclouds of Ophiuchus and Scorpius are thinner than their glorious counterparts in Cygnus, Scutum, and Sagittarius, they still are photographically magnificent.

Let us begin our tour by directing our telescopes to the west portal of this starry international park. The entrance is formed by β Librae on one side and α on the other. They have Arabian names that anyone can recall who has taken a memory-training course—Zubeneschamali and Zubenelgenubi; in plain English, north claw and south claw. Here sleep memories of the days when the Scorpion's arms were long enough to include Libra, or the Claws, as Aratus, Greek stellar poet, calls it seven times.

Tradition says that β Librae is green. Look for yourself; then perhaps you will decide that it is blue like Rigel. In any case, it is 217 light-years from earth.

Because the park gate is measured in light-years, no ranger waits to collect an admittance fee. We turn our telescopes from β southward, past ι, and slow to see our first major spectacle, a globular cluster, NGC 5897 (19^6), small and dim when viewed through amateur telescopes because it is much farther from earth than our earth is from the galactic center.

The mythological figure of the Scorpion, drawn by Thomas Voter after Bayer. This is the ninth constellation of the zodiac.

The skylands through which we tour are noted for globular clusters, as the Mojave Desert is famous for Joshua trees. These spheroidal monuments, miniature universes, appear outside the main mass of our Milky Way system, and nearly one third hover around Scorpius, Ophiuchus, and Sagittarius, constellations surrounding the galactic center. Altogether our galaxy has about 100 globulars, but it yields the prize to M31 in Andromeda, with a total of 140.

The nearest globular in our galaxy is 20,000 light-years from your home town; the farthest about 185,000. Homer says that Zeus and Athena often came down to earth and later ascended skyward. Let us assume that they did not stop at Olympus, but sought the true heavens. If their journey began when the *Iliad* was being written, and if they traveled with the speed of light, they now would be 2,800 light-years from Athens, or only a seventh of the distance to the nearest globular.

The S-shaped dark nebula in Ophiuchus, from a photograph by John C. Duncan at Mount Wilson Observatory. Compare the object's appearance here with that it has on the back cover.

Even though solar systems may be rare, still each globular cluster may have at least one inhabited world. Visiting such a planet, by imagination, we should find the night sky glorious, if not garish, with many thousands of stars, a large number of which would outshine all of our 20 1st-magnitude stars grouped as a unit.

The moon may have been made for lovers, as Abbe Marignan decided in de Maupassant's story, but what value would moonlight have in a globular-cluster world? There, too, stellar occultations would be too common.

Daydreams like these may help us appreciate NGC 5897 and other seemingly small globulars. It is some 35,000 light-years away. There may be an error of 5,000 light-years here, either way, but why worry? A light-year is too much for us anyhow, because no brain lives long enough to count the miles in a light-year.

From the Libra globular we pass to three doubles in the upper part of Scorpius: β, white-blue, separation about 13″, 204 light-years from us; ν, a wide pair; and ξ, 7″, distant 84 light-years. Then we swing northwest to upper Serpens, to the great globular M5. Taken as a unit, M5 appears as bright

as M22 in Sagittarius and slightly more luminous than M13 in Hercules, the best-advertised globular. From this M5 spheroidal showpiece we turn to examine two stars, β, in the head of Serpens, a wide blue and yellow double, and nearby δ with a separation of 4″, 170 light-years distant.

Thence we pass to Ophiuchus, the Serpent Holder, memorial to Aesculapius, Greek physician. In the central region of this constellation three globulars form a sagging watch chain across the breast of the great healer. First we spy M12, about halfway between κ and ζ; its distance is about 30,000 light-years, and its visual magnitude is 6. Second, east of M12 and slightly south, we see nearby M10, a little brighter and smaller than its neighbor, and about as far from us. The third cluster, M14, glows in central eastern Ophiuchus, between β and η, nearer β. It is roughly twice as far away as the others; so we are not surprised to find it less conspicuous.

Next, we move northeastward to the right or east shoulder of Ophiuchus, marked by bright β and less resplendent γ. Just east of them, at the lower end of the Door starcloud — resembling a door swinging out from the Milky Way —is a delightful asterism, the Bull of Poniatowski. This tiny V of five stars was named in 1777 in memory of a Polish count, by whose courage Charles XII, Sweden's greatest king, escaped death while fighting against Peter the Great. We notice the two eyes of the Little Bull; 67, a wide double, and 70, a close yellow-red combination.

Then we glide southward along the Serpent's tail, which lies in the Great Rift, and turn westward to observe another globular, M9, east of a line between η and ξ in Ophiuchus. M9 is smaller than the spheroidal clusters of the central region of this constellation and more remote from earth.

The Serpent Holder stands in a mist-haunted region. His right foot, marked by θ and two other stars, is just above the huge black Pipe nebula, naked-eye marvel, and his left foot ends in ρ Ophiuchi, 5th-magnitude star, a pleasing double, with separation of 3″. Three big dark lanes, nearly parallel, run into the dark and bright nebular chaos lying between ρ and Antares. It is a curdled, awesome place, but as our eyes are not so sensitive as photographic plates we cannot directly perceive the ominous landscapes through which we move.

From ρ we cross a relatively short space, to Antares. This great sun, 250 light-years from earth, rivals Mars only in color; in size it is about as large as the orbit of the ruddy planet. It has a famous green companion, to glimpse which an amateur needs keen eyesight, a big telescope, or spry imagination.

Near Antares we inspect M4, choice globular distant more than 20,000 light-years. About halfway between σ and β Scorpii is another spheroidal cluster, M80, small and dim and more than twice as far away. The main mass of the Scorpius starcloud lies north and east of a line from Antares through τ and ε to μ. Within this richness shine two other globulars on which we gaze, M19, between Antares and θ Ophiuchi, and M62 Scorpii farther south, both small and dim.

Our telescope swings southward. After passing between a small open cluster, 5564, and the naked-eye double, μ Scorpii, it pauses momentarily over three noteworthy clusters between μ and ζ. The first, NGC 6242, has a diameter of 10′ and consists of 40 stars. H 12 (5204), the second, is a brilliant centerpiece. It is 40′ in diameter and has 200 stars. Next and just above ζ shines NGC 6231 (3651h), 15′ with 120 suns. They are too low in our sky to win the attention that they deserve.

Following the curving tail of the Scorpion, we slip by the globular NGC 6388, small and difficult, probably 50,000 light-years from earth. Below the tail, it marks the point farthest south in our itinerary. Now we ascend northward past the Scorpion's sting, to those old favorites, M7 and M6, choice open clusters, forming a triangle with λ of the forked tail tip. Each has 50 stars, though M7 is the larger.

Curving northward, we pass right over the center of our galaxy, south of the Pipe nebula, and continue north till we reach cluster M23 in Sagittarius. M23 delights us with its 120 suns, a huge chandelier hung near the Great Rift. We take a big look; then, continuing eastward, we sweep across the small Sagittarius cloud, in photographs somewhat like the Keyhole nebula of Carina, but with two dark eyes. This starcloud is terminus of our exciting midsummer night's dream, in which, we may pretend, we have broken the speed limit because we have moved across spaces measured by many light-years, and so by magic imagination have gone faster than light.

Yes, in a way we have done the impossible, and we have seen wonderful things. And we return both humble and proud—humble because we know that our dear earth is imperceptible among billions of other spheres in the Milky Way; proud because we live in a world that has evolved astronomers, who have made us conscious of so much unconscious grandeur.

The end of the journey described here is at the small Sagittarius cloud in the top center. To its right is cluster M23, and to its left is M25, both ¾ inch from the top of the picture. The tail of the Scorpion is in the lower right. The tip of Sagittarius' arrow is two inches from the left side and 2¾ inches from the bottom. Zeta Sagittarii is close to the left edge, midway from top to bottom. The diffuse nebulae, M8 and M20, are conspicuous in the upper center above the great Sagittarius cloud in the center of the picture. Harvard Observatory photo.

NEWS NOTES

By Dorrit Hoffleit

CONFERENCE ON THE CONSTANTS OF ASTRONOMY

Most of the constants now used internationally in the computation of ephemerides have been in use for 50 years. Some are known to be inconsistent with one another. Dr. G. M. Clemence, of the U. S. Naval Observatory, gives a brief account in *Science* of an international conference held in Paris the last week of March, under the auspices of the Centre National de la Recherche Scientifique, to discuss these matters. Nineteen delegates from six countries attended; the other Americans were Drs. Dirk Brouwer and H. R. Morgan.

Dr. Clemence comments: "The conference was marked throughout by a unanimity of opinion that was quite astonishing in view of the legitimate differences that might reasonably be expected on the highly technical matters discussed." It was found undesirable to make changes now in the fundamental constants, as "it is not yet clear what values would be preferable to adopt in their place" that would not themselves be subject to further revision within a few years.

An important resolution concerned the fundamental unit of time heretofore based on the earth's rotation. As that rate is variable, it was proposed to adopt instead the mean period of the earth's sidereal revolution around the sun. Six of the nine resolutions adopted were in the form of recommendations addressed to the International Astronomical Union.

FIRST NEW COMET OF 1950

This year has not yet been very productive of new comets. In April Dr. G. Van Biesbroeck at the McDonald Observatory announced his rediscovery of Comet d'Arrest. The second discovery of the year is probably a new comet. It was found by Dr. R. Minkowski and Robert G. Harrington on a plate taken with the 48-inch Schmidt telescope in the course of the National Geographic Society - Palomar Observatory Sky Survey, on May 19th at 2:32 a.m. PST. The 8th-magnitude object was then at right ascension $18^h\ 16^m.8$, declination $+12°\ 3'.2$, in the constellation Ophiuchus.

It was described as having a tail about one minute of arc in length. How long this is in miles cannot be ascertained until the approximate orbit of the comet has been determined. Dr. Minkowski estimates that the comet is probably farther away than the sun from the earth and that it may be receding from the sun. Possibly it was brighter before it was discovered, but then it was in the Milky Way where it would have been more difficult to distinguish from nearby bright objects. At the time of discovery it was moving about $2^m\ 7^s$ west and $4'.4$ south per day.

STUDIES IN GRAVITY

Since the days of Sir Isaac Newton, little practical investigation of the fundamental properties of gravity has been done. Science Service reports that John T. Pettit, of the University of California at Los Angeles, is now taking up such investigations. Not only are the oceans affected by the pulls of the sun and moon which cause the tides, but the solid surface of the earth is also distorted. The distortion may amount to about four feet. Mr. Pettit is using a gravimeter for measuring the gravitational distortion. The device is so sensitive it can measure changes to an accuracy of one part in a billion.

Most studies of gravitational effects have been theoretical, including Einstein's unified field theory. Mr. Pettit's much-needed work will fill an observational gap.

"BONNER DURCHMUSTERUNG"

Professor Friedrich Becker, director of the observatory at Bonn, in western Germany, recently attended a meeting of the Royal Astronomical Society in England and reported briefly on the work of his observatory. Of particular interest was his announcement that work has been in progress on the preparation of a new edition of the famous and well-nigh indispensable *Bonner Durchmusterung* originally begun by Argelander. The new edition of the southern catalogue is ready.

Other work at Bonn that Becker mentioned includes studies on the question of the existence of the local cluster, statistical studies of star chains in the Milky Way, and re-observations of the AG zone catalogue (the principal task of the observatory). There are also plans for combining measurements made by Kustner some 40 or 50 years ago on open clusters with new plates, in order to obtain the proper motions of the clusters and possibly some information on their internal motions.

GEOPHYSICAL LABORATORY

Science Service reports that scientists at the University of California at Los Angeles have devised a "torture chamber" for the purpose of ascertaining how mountains and oceans were formed and what causes earthquakes. At 22 miles below the surface of the earth, pressures reach some 150,000 pounds per square inch. This occurs seven times farther down than man has yet penetrated. One of the new laboratory machines enables scientists to experiment with such pressures. Rocks subjected to these pressures can be examined for creep and flow and possible changes in structure. The experimenters can also make rocks by compressing loose sand into solid quartzite. David Griggs, John Handin, and Wesley Miller, of the university's Institute of Geophysics, are conducting these experiments in the laboratory, which was partly built through a grant from the Office of Naval Research.

PLUTO'S DIAMETER

The apparent diameter of the outermost planet, Pluto, was measured in March by Dr. G. P. Kuiper, of Yerkes and McDonald Observatories, employing the 200-inch telescope on Palomar Mountain, during a rare opportunity to make visual observations with that primarily photographic instrument. The superior resolution of the 200-inch enabled Dr. Kuiper to make a measurement that replaces the preliminary result of his earlier observations of Pluto with the 82-inch McDonald Observatory reflector (see *Sky and Telescope*, March, 1950, page 103).

By comparison with a disk meter, Pluto was found to have an angular diameter of 0.23 second of arc, corresponding to an actual diameter of about 3,600 miles, about midway between the sizes of Mercury and Mars. The uncertainty in the measurement is believed to be about five per cent. The reflectivity or albedo of the distant planet was found to be 17 per cent, compared with 15 per cent for Mars. If a normal density is assumed, the mass of Pluto may be about 1/10 that of the earth, whereas that indicated by perturbations of Neptune is about nine times this amount.

In the CURRENT JOURNALS

The Latent Image, by J. H. Webb, *Physics Today*, May, 1950. "A few quanta of light leave their imprint on photographic emulsion by forming a few atoms of silver and thereby photographic reproduction is possible. This article is a discussion of the physical aspects of the latent image process."

Planetary Nebulae, by Olin C. Wilson, *Leaflet* No. 253 of the Astronomical Society of the Pacific, April, 1950. "Some of the scarcer types of celestial objects excite an interest among professional astronomers far out of proportion to their numbers among the general stellar population."

How Narrow a Line Can We See on Mars? by David W. Rosebrugh, *The Strolling Astronomer*, May, 1950. The author describes experiments he has carried out for the ultimate purpose of evaluating observations of the much speculated-upon planet. Planetary observers are encouraged to make similar tests of their own seeing limitations.

Visual Double Stars - II

By Otto Struve, *Yerkes and McDonald Observatories*

AT THIS TIME we shall speculate concerning some recent work on the orientation of the orbital planes of the visual binaries. This subject is not new. Astronomers have been wondering for a long time whether the orbit planes are distributed at random or reveal some tendency toward parallelism with the plane of the galaxy, as might be expected from cosmogonical considerations. Whatever the exact process may be that leads to the formation of a double star, it must involve the conservation of certain properties of the rotational motion that existed before the binary was formed. Since we know that most of the orbital motions around the nucleus of our galaxy are distributed symmetrically with respect to the plane of the Milky Way, it would be reasonable to expect that the orbital planes of the double stars should also be oriented parallel to this plane. At the same time we recognize that the turbulent motions that are undoubtedly present in the interstellar material would tend to redistribute the rotational motions in a haphazard manner. Perhaps little remains of the original preferential plane when we consider a small volume of interstellar space.

In a different context, we encounter a similar problem when we discuss the axial rotations of the stars. They, too, must have come from the original rotation of the primordial medium out of which the stars were formed. But observations show that in large volumes of space there is no preferential direction in which the rotations take place. If we examine the *B*-type or the *A*-type stars of our galaxy, we find that the axes of rotation are oriented in all possible manners. On the other hand, there is a strong suspicion that in closely knit groups of stars, such as the Pleiades, there remains a tendency for the axes of rotation to be parallel.

The study of the orbital planes of visual binaries is difficult, first because we have only a limited number of pairs for which the observations are sufficient to yield reliable orbits, and second because there is an intrinsic uncertainty regarding the angle of the inclination which the plane of the orbit makes with the tangential plane of the sky. This angle is designated by *i*, and it is theoretically impossible, using visual observations alone, to determine the sign of this angle: The observations are exactly represented with either a positive or a negative value of the inclination. This is shown in Fig. 3. We have at the top two ellipses of identical shape with the same direction of apparent motion of the companion star with regard to its primary. But in the one case the star is nearest to us when it is moving from left to right, while in the other case it is farthest from us when it is moving in the same direction. If we compute the orbital elements, we find that identical elements are obtained for these two ellipses except for the inclination, which is positive in one case and negative in the other; the absolute amount being the same for the two pairs. The two elliptical paths are exactly the same as far as the visual observer can tell. The uncertainty can be removed when spectrographic observations are available, because they permit us to determine at which *nodal point* (extreme left and right of each ellipse in Fig. 3) the companion is approaching and at which it is receding.

In the two lower ellipses the motions of the companion are reversed. This can be expressed by distinguishing between northern and southern polarities in the orbits of the binaries. We call the polarity northern when from its pole the orbital motion is seen to be counterclockwise and we call it southern when the motion appears to be clockwise. In Fig. 3 the two lower ellipses have opposite polarity from the two upper ellipses.

There have been a number of investigations concerning the orientations of the orbital planes, but the results have often been contradictory. In the earlier work the material was insufficient to distinguish between positive and negative values of the inclination. For example, T. J. J. See, A. Everett, and W. Doberck made no distinction between the true and the false values of the inclinations, and found a uniform distribution. However, the lack of information concerning the true sign of *i* made their work inconclusive.

In 1907, T. Lewis and H. H. Turner attempted to distinguish between the true and false inclinations by a statistical procedure and concluded that the orbital planes have a tendency to be oriented at right angles to the plane of the Milky Way — a result which was so strange that it invited further study. J. Hopmann and E. Kreiken indicated a trend in the opposite direction.

A real advance was made in 1929 by Y. C. Chang, who obtained the sign of *i* for 16 pairs, with the help of the radial velocities, and especially in 1933 by W. S. Finsen, who increased the material to 28 objects. For each pair he computed the orientation of the orbital plane and from it the location upon the celestial sphere of the north pole of each orbit. He then plotted the resulting poles, in galactic co-ordinates, upon a net in which equal areas in the sky are retained as

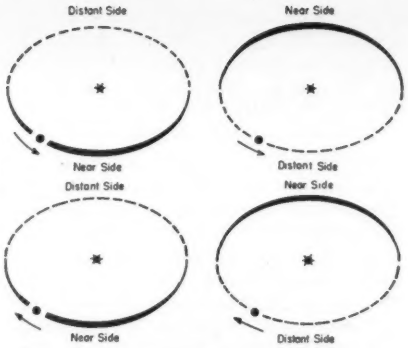


Fig. 3. The four ellipses illustrate the apparent orbits of four double stars. Although their shapes are the same, they correspond to four different cases depending upon the sign of the inclination and the direction of the companion's motion.

equal areas in the diagram. The result is shown in Fig. 4. The galactic longitudes are given only from 0° to 180°. For binaries whose north poles have longitudes between 180° and 360° Finsen plotted the south poles. In the figure, a crossed circle marks a north pole; a circle with a dash marks a south pole. When the inclination is 0° (the apparent orbit is identical with the true orbit) or 90° (the apparent orbit is a straight line), there is no uncertainty about the true and false inclinations. Finsen included four stars of this kind, even though no radial velocities were available, and the polarity could therefore not be determined. These systems are shown as open circles.

Fig. 4 shows that the distribution of the 28 poles is fairly uniform and that, for this small amount of material, the orbital planes are inclined at random. But there is a tendency of the south poles to concentrate near the south pole of the galaxy, while the north poles seem to prefer the northern latitudes. Finsen believes that this "may well be accidental," and Aitken concluded in 1935 that "we may accept this as the best answer to the question on the basis of existing data." But perhaps we should search again, with all the material now available from radial velocity measurements, whether the direction of the galactic rotation of our Milky Way system may not, after all, have a direct bearing upon the directions of the orbital motions of double stars.

In 1946, this question was reopened by Miss S. V. Koslovskaya on the pages of the *Astronomical Journal* of the Soviet Union. The method of Chang and of Finsen is applicable only to a small number of systems. In order to evade this difficulty, she returned to the large amount of material for which the sign of *i* is indeterminate, and computed the locations of all north poles — true and spurious — for those systems for which they are not very far apart in galactic

latitude. She used only those systems for which the angular distances from the north galactic pole of the true and false poles of a binary differ by less than 13 degrees, and plotted the average value of the angular distance in Fig. 5. This curve shows the observed number of pairs for each orientation at increasing distances from the galactic pole; 148 orbits are represented. Miss Koslovskaya remarks that if the orbit planes were distributed at random the orbital poles would be uniformly scattered over the entire celestial sphere and the frequency distribution would fit the dotted curve in Fig. 5. It is a sine curve, rising to a maximum at 90° from the galactic pole, and differs radically from the observed curve.

On the other hand, there is a remarkable similarity between Miss Koslovskaya's result and a theoretical distribution curve computed by the Russian academician O. J. Schmidt. The latter's theory is, however, quite incomprehensible to the present writer. It rests upon the strange assumption that a binary is formed when two stars passing one another in their galactic orbits reach their shortest possible distance. Their relative velocity at this instant is computed by considering only the undisturbed galactic orbits. The assumption is made that at this very instant the two stars begin to revolve around one another, and the relative velocity previously computed is set equal to the elliptical velocity at either periastron or apastron, as the case may be.

In more recent papers and discussions, Schmidt (who is director of the Soviet Institute of Theoretical Geophysics) and his followers have attempted to defend this oversimplified capture theory in the light of simplifications which are often necessary in other fields of astronomy and physics. But even if the assumptions are granted, it is difficult to follow the mathematical derivation of the frequency curve obtained by Schmidt, and it is even more difficult to visualize the manner in which a frequency maximum at galactic polar distance 64° can result. Thus, the mathematics involves some arbitrary assumptions whose influence is not investigated. Intuition should lead us to expect that captures in galactic orbits will produce binaries with orbital planes that coincide with the plane of the Milky Way. The corresponding poles will then cluster in the vicinity of the galactic poles, and the frequency curve should have a maximum near 0°. If there is, in addition, a general random scatter, the resulting curve might conceivably show an excess of binaries for small angles and a deficiency at 90°.

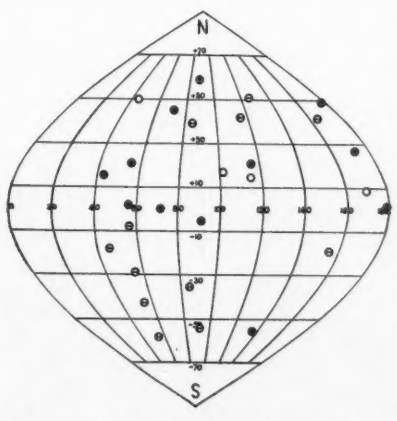


Fig. 4. The distribution of the poles of 28 binary star objects on the celestial sphere, according to W. S. Finsen.

But it is futile to pursue this question further because another Russian astrophysicist, V. V. Sobolev, in 1948 rediscussed the observational results of Miss Koslovskaya and attributed the form of the frequency curve found by her to the effect of observational selection. Let us see how this may happen. Her procedure resulted in her choosing preferentially those binaries which are located either near the central line of the Milky Way, or near the galactic poles. Suppose, for example, that a double star is in the Milky Way. Its orbital plane may make any angle with the tangential plane of the sky. Since we ourselves are also in the plane of the Milky Way, the perpendiculars erected at right angles to the true and spurious orbit planes intersect the celestial sphere at two points which are equidistant from the galactic pole. If the binaries for which orbits are available really have a random distribution of their planes, the orbital poles will be distributed uniformly over the sphere, even though the limitation of Miss Koslovskaya's computations is adopted, and this would give us the dotted curve in Fig. 5.

In reality, it is much easier to observe and derive orbits when the apparent path of the companion around the primary is wide open ($i = 0°$) than when it is almost a straight line ($i = 90°$). The former, being more often found in our catalogues than the latter, produce an apparent drop in the observed frequency curve at 90° — just as observed.

The systems near the galactic poles have the opposite tendency. But they are far less numerous than the systems in and near the Milky Way. Statistically, there are not enough of them to reduce appreciably the tendency of the Milky Way binaries to give us a minimum at 90°.

The exact formulation of this problem in mathematical statistics by Sobolev is a real gem in the technical astronomical literature of the past several years. It leads to an integral equation which combines the observed frequency distribution of the angle of inclination, i, and the theoretical distribution of the angle from the galactic pole. The final conclusion is that observational selection, instead of a preference of the orbits to be oriented in any specific manner, explains the result of Miss Koslovskaya. But this does not mean that if all orbits were known they would necessarily give a random distribution of the orientations of their orbit planes.

Sobolev's conclusion agrees with that of D. Barbier who, in 1946, investigated 74 double stars for which i is close to 90°. For these pairs the true and false orbital poles are diametrically opposite,

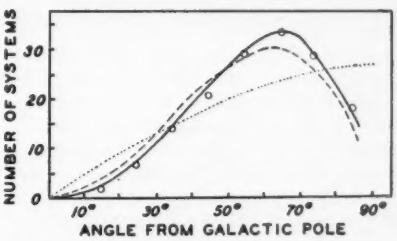


Fig. 5. The continuous line and the circles represent the numbers of binary stars with average orbital pole positions oriented according to increasing distance from the galactic pole (horizontal scale) according to the work of Koslovskaya. The dotted curve represents the distribution that would be expected were the planes distributed at random. The dashed curve is one obtained theoretically by O. J. Schmidt.

and if we are not interested in the polarity, we can regard the false pole as the south pole of the true orbit, and examine the distribution of the entire material.

In conclusion, attention may be called to a spectroscopic method of finding the distribution of binary orbit planes to the Milky Way. The velocity curves of spectroscopic binaries depend upon the orbital inclination: When $i = 90°$ the observed Doppler displacements give the true velocities of the two components; but when $i = 0°$ the Doppler displacement is zero. Hence, if all binary orbits were parallel to the Milky Way, we should observe velocity curves with large amplitudes for binaries located in the Milky Way; binaries located at higher galactic latitudes would have smaller amplitudes. This method was first used by G. Shajn in 1926, with the conclusion that the orbital planes may, in fact, be oriented preferentially parallel to the Milky Way. But there is some reason to suspect that this result is produced not so much by the orientation of the orbit planes as by the well-known difference in galactic concentration of the most massive stars. Hence, if Shajn's material did not completely differentiate between binaries having different masses, his conclusions would remain somewhat unconvincing, despite the fact that the principle which he used is entirely correct.

Amateur Astronomers

Middle East Regional Convention Held at Norfolk

A SUCCESSFUL Middle East regional convention was held at Norfolk, Va., May 5-7, with eight of the 18 societies in the region represented. Several members-at-large of the Astronomical League were in attendance, as well as representatives from amateur groups in what it is hoped will soon be the Southeast region. Also present was Charles H. LeRoy, president of the league, who gave a report to the convention on the expanding aims of the organization.

On Friday evening, there was a lecture on solar radiation by Aubrey Hustead, of the Amateur Astronomers Society of Norfolk, host society for the convention, followed by an open house at the group's Lakeview Observatory.

Saturday morning's business session included individual reports of the member societies on their year's activities. A session on observing programs included a paper by F. H. Cox, of Norfolk, on the "Primordial Solar System." The balance of the session was divided into three parts in which members of the American Association of Variable Star Observers, the Association of Lunar and Planetary Observers, and the American Meteor Society, described these organizations, their programs, and told how to get people started on observing programs of their own. A 22-page mimeographed pamphlet was given to each person, containing helpful information on these same programs as well as other data. It is planned to make these pamphlets available to all societies in the Middle East region. Much satisfaction was expressed for the information received at this session of the convention.

In the afternoon regional officers for the coming year were elected: T. W. Stone, of the Richmond Astronomical Society, vice-chairman; Mrs. Belva Lu-Caric, of the Beaver County AAA, secretary; Maurice Parson, Lansing Amateur Astronomers, was re-elected treasurer, and the undersigned was re-elected chairman.

An instrumentation session was led by Leo Schoenig, of the AAA of Pittsburgh. Not only did he show several interesting developments of telescope parts and accessories, but he called on various delegates to display and tell about equipment and to report progress in the region on building and improving our observing equipment. This session, as always, proved very worthwhile and, as usual, too little time was scheduled for it.

The closing session, conducted by Gordon Urban, AAA of Pittsburgh, regional chairman for junior activities, brought out that junior activity is at a low ebb in regional affairs, many societies not bothering even to answer the inquiry as to whether or not they include juniors in their membership. Several papers by juniors had been forwarded to be read at the convention but time permitted the reading of only one of these.

One point repeatedly brought out at the convention was the difficulty of securing information from member organizations.

The exhibits were outstanding, ranging from a beautiful miniature model with an actual ⅜-inch mirror to a 12-inch reflector with several novel features. There were many exhibits of equipment, of literature, forms and data from the AMS and the AAVSO, and ideas for star parties and other astronomical group activities. Society programs and publicity were displayed as well.

About 75 persons attended the dinner Saturday night, May 6th, when a lecture on "The Atmosphere of Venus" was given by Dr. James B. Edson, of the Office of the Chief of Ordnance. His description of amateur-made equipment and how it was used for original investigations was certainly an inspiration to those amateurs who heard Dr. Edson's talk. The late evening activity was a field trip to the Cape Henry Weather Bureau Ship Reporting Station.

Conducted sightseeing was the order of the day for Sunday, and it was climaxed by our boarding the battleship *Missouri*, "Mighty Mo," docked at the Navy Yard.

G. R. Wright, chairman
Middle East Region
Astronomical League

CONFERENCE OF WESTERN AMATEUR ASTRONOMERS

THE STANFORD UNIVERSITY campus at Palo Alto, Calif., will be the site of the second annual conference of western amateur astronomers, August 14-16. A meeting hall and exhibit room, as well as living quarters, have been made available by the university. The accommodations at Roble Hall are for single persons and married couples; children under 16 may not stay at the dormitory. The cost is $3.00 per person for one night, $6.00 for two nights, $8.00 for three nights, and $10.00 for four nights. Meals at $5.15 per day will be served at the Union Cafeteria on the campus, where both adults and children may eat.

A tentative program announced by the convention committee chairman, H. A. Wallace, 2925A Jackson St., San Fran-

The group photograph at the regional convention of the Middle East region of the Astronomical League, at N[illegible], Va.

cisco 15, Calif., provides for an opening session at 9:30 Monday morning, August 14th. The afternoon will be devoted to talks and papers, and there will be a banquet and star party that evening. On Tuesday, morning and afternoon sessions will be followed by a public showing of the film, The Story of Palomar, and a lecture by Dr. Seth B. Nicholson, of Mount Wilson and Palomar Observatories. Stanford University and the Astronomical Society of the Pacific are joint sponsors of this part of the program.

Further time for papers and for exhibit inspection is available Wednesday morning, and that afternoon there will be a visit to Santa Clara University, where its observatory, famous for solar studies, will be inspected. That evening Lick Observatory on Mt. Hamilton will be visited, with a box supper on the mountain. The 36-inch refractor has been put at the disposal of the convention by Dr. C. D. Shane, director of Lick Observatory.

Transportation by private car on the Wednesday trips will be provided for those in need of it. The undersigned should be notified by July 15th by all persons wishing accommodations in Roble Hall at Stanford University. Information on outside accommodations is also available, as well as further details on the conference.

(MRS.) DOROTHY R. ROSSITER
Peninsula A. S. Convention Committee
922 Roble Ave.
Menlo Park, Calif.

NEW LEAGUE MEMBER

The newly formed Astronomical Society of North Carolina State College, with a membership of 22, has joined the Astronomical League. The president of the group is Charles F. Campen, Jr., and the society may be addressed c/o Physics Department, North Carolina State College, Raleigh, N.C.

Early in June the Astronomical League had 50 organization members and three junior organization members. There were also seven members-at-large.

at N[illegible], Va., May 5-7, 1950.

Members and guests at the spring meeting of the American Association of Variable Star Observers, Pennsylvania State College.

AAVSO Meets at Pennsylvania State College

ON May 5th and 6th, the American Association of Variable Star Observers held its 1950 spring meeting on the campus of the Pennsylvania State College, at State College, Pa. The attendance was smaller than usual at such meetings, but enthusiasm and interest in the program was at an all-time high.

Dr. H. L. Yeagley, director of the Penn State Observatories, addressed the association on Friday evening, describing his very interesting researches on the subject of bird navigation. At the business meeting on Saturday morning, 19 new annual memberships were approved, a newly revised constitution and by-laws was officially adopted, and it was announced that plans have already been made to hold the 1951 spring meeting in Washington, D.C., at the invitation of the Georgetown College and U. S. Naval observatories, and the National Capital Astronomers.

The sessions for papers included several unusual items, such as "High Temperature Industrial Uses of Solar Energy," by W. F. Mullen, of State College, who acted as program chairman for the meeting, and "Introductory Research in Astrophysics," by William Tifft, young AAVSO member who has recently received a Westinghouse science talent award. Also on the program was a detailed review of the present variable star observing program, by the recorder, Mrs. Margaret W. Mayall, and several papers on solar observing contributed by the AAVSO president, Neal J. Heines. The paper which produced the most interest and discussion was probably that of Carlos Garcia-Mata, of New York, who presented a careful analysis of the light curve of Mira Ceti, showing that the fluctuations of this well-known variable can be represented by the same type of simple equation which he has already applied successfully to the problem of variations in sunspot cycles.

An informal luncheon was served on Saturday at the Nittany Lion Inn, and members and guests were given ample opportunity to visit the Penn State Observatories, which contain three excellent telescopes. Members of Alpha Nu, the local student astronomical fraternity, conducted visitors through various instrument making shops and other exhibits, all of which indicated that there is plenty of interest in astronomy at Penn State, although there is at present no separate department of astronomy there.

CLINTON B. FORD
AAVSO Secretary

THIS MONTH'S MEETINGS

Dallas, Tex.: The Texas Astronomical Society will meet Monday, July 24th, on the lawn of W. L. Oliver, 1446 Glen St. The group will continue constellation study, with Ted Gangl as principal speaker. Telescopes will be available and the public is invited.

Indianapolis, Ind.: "The Summer Stars" will be the subject for discussion by Clark B. Hicks at the July 2nd meeting of the Indiana Astronomical Society, at 4053 Ruckle St.

Kalamazoo, Mich.: The Kalamazoo Amateur Astronomical Association will meet at the home of Dr. and Mrs. H. R. Cobb, 3319 Knox Ave., at 8 p.m. on July 15th. H. V. Hilker will speak on "Cosmogony."

Los Angeles, Calif.: Dr. William A. Baum, Mount Wilson Observatory, will speak on "Photometry," at the meeting of the Los Angeles Astronomical Society, 7:45 p.m. at the Griffith Observatory.

Wellesley, Mass.: The annual convention of the Astronomical League will take place at Wellesley College, Saturday through Tuesday, July 1st to 4th, at the invitation of Dr. John C. Duncan, Whitin Observatory. The host societies are the Amateur Telescope Makers of Boston, the American Association of Variable Star Observers, and the Bond Astronomical Club, all with their headquarters at Harvard College Observatory.

Yakima, Wash.: The Northwest region of the Astronomical League will meet in the Pacific Power and Light Company auditorium on Saturday and Sunday, July 29-30. The Yakima Amateur Astronomers is the host society.

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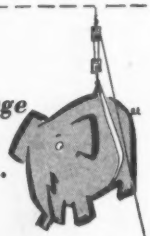

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BOOKS AND THE SKY

A CONCISE HISTORY OF ASTRONOMY

Peter Doig. Chapman and Hall, Ltd., 37-39 Essex Street, Strand, London W.C.2, England, 1950. 320 pages. 21 shillings.

ASTRONOMY is proud of its inheritance from the past, and in most books on the subject there are commonly found pleasant bits of capsule history. A familiarity with the tradition and the lore of the science is acknowledged a praiseworthy element in the background of any astronomer, amateur or professional. For a generation it has, however, not been easy to comply with suggestions that one read in the history of astronomy. The last book in English to trace the development from the beginning was a 1921 unrevised reprint of George Forbes' little 1909 volume which contained only 154 pages.

Those whose German is fresh consult Ernst Zinner's **Die Geschichte der Sternkunde** (1931) and allow for the bias, but the standard work most cited is Arthur Berry's **A Short History of Astronomy** (1898). Thus we have to go back over 50 years to find a sound treatise on what it is agreed we should all know something about.

In the meantime we have had interesting reading at various levels covering particular periods, for example, **Sun, Stand Thou Still** by Angus Armitage, and **A Hundred Years of Astronomy** by R. L. Waterfield. Besides these, some easy-going biographies are available, and astronomy is generously treated in most histories of science. There has, nevertheless, simply not been the right history on sale at the bookshop to supplement a basic knowledge of the science of astronomy itself.

It is in this atmosphere that Peter Doig's **A Concise History of Astronomy** is warmly welcomed. The author is known for his **Outline of Stellar Astronomy** (1947) and still more for his excellent editing of the **Journal** of the British Astronomical Association. With this new book he scores heavily.

If the varied circulation of **Sky and Telescope** may be lumped and averaged, it can be said that here is ideal reading for all but those on the fringes. If you understand what is in an elementary textbook, Doig is your man. He will, as no one else, piece together the past of astronomy and then carry you forward to the frontier where the new work is being done.

The special advantage of the volume for most of the readers of this magazine is that its substance and pattern could be described as "the position of astronomical observation and theory in 1949 with an extensive historical introduction." Factors which have influenced the development of today's view of the observable universe are well explained. The pre-telescope period has been kept in such modest compass that even with a total of 309 pages of text, 246 are devoted to Galileo and later. More than a third of the book deals with the 20th century.

In subdividing the material after 1800 by topics, Mr. Doig makes easy the investigation of our advancing knowledge of such topics as globular clusters. The sun is, of course, discussed at considerable length in the light of modern knowledge. This treatment is typical of subjects which have seen greatest change in ideas in recent decades. The style and the absorbing interest are such, however, that most people will read the volume happily straight through and later consult it for specific items.

Now, let us consider the book in terms of what astronomy needs in the way of

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James Oliver Hogg, Jr.

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a full-dress history with complete references, or at least exact dates of publication, in order to facilitate identification of original papers. It does not supersede earlier work to 1900 except in details (for instance, recognition of Neugebauer's Babylonian studies), and scholars will find little history as such in the last chapters. Professional astronomers will still have to use Zinner and the **Jahresbericht** to put together historical matter for all but popular lectures.

With the allotted space and the audience he had in mind the author of **A Concise History** could not make this more than a "handy reference book useful to students," as he himself describes it in the preface. He writes from the point of view of today, answering important questions on how astrophysical theories grew to their present acceptance. In doing this he allows for the reader with modest technical knowledge by including substantial explanations. Occasionally, the account of what the best people think tends to leave out the names of those who did the thinking. In this way many second-string and a few top-drawer Continental astronomers fail to get mentioned, with some not completely justified gain in ease of reading. At times toward the end exposition submerges history, but many readers will like the presentation the better for that.

The giants of the past are given the usual thumbnail biographies in the early chapters, while the whole book points toward the work of the strong men of our time. From this approach the reader gets two worthwhile dividends: a rapid review of the recorded history of astronomy to 1900 and a first-class grounding in how to fit results of current research into the mosaic of what we know and don't know about celestial bodies and their organization.

In return for time spent, no more rewarding book in or near its field has been published for years.

JOHN W. STREETER
Vassar College Observatory

THE EXPLANATION OF LIFE

Stephen Th. Bornemisza. Rascher Publishing House, Zurich, 1949. 272 pages. Price not given.

DR. BORNEMISZA, a geophysicist, biologist and botanist, has here attempted to treat the problem of the nature of life, and he evidently believes that he has solved it. At least he has given his volume the title "**The** Explanation of Life" (boldface mine), and the subtitle "The real background to nature."

To attempt a survey of his argument would be useless in less than several pages, but one can say that he combines a complete physical determinism with a philosophy of "Eat, drink, and be merry, for tomorrow you die." The argument passes through a rather Whiteheadian discussion of organisms, via an analysis of entropy in physiological processes to conclusions about the nature of pleasure and pain, and psychological motivations. Perhaps the word "argument" is ill-chosen. Although the author speaks as though his reasoning had mathematical certainty, the individual steps are usually based on analogy and intuition.

While some of the theories advanced by Dr. Bornemisza are new to this reviewer, they seem so confused and inconsistent as to be beyond discussion. The most coherent part of the book is the section on metabolism and entropy, and here less is said than can be found in Edwin Schroedinger's brilliant little book, **What is Life?**

To avoid his stilted and painful English, Dr. Bornemisza should have written his book in German (which one gathers to be his mother tongue) and had it translated. Philosophical concepts seem to be transliterated in the author's mind from German to English so that, for example, the Whiteheadian concept of a "prehension" is rendered by the word "taking," a totally inadequate expression probably coming from a literal translation of the German "Nehmen." Such inept transliterations plus strained constructions and germanic neologisms produce confused 10-line sentences whose content could be clearly expressed in 10 words.

The author also seems to feel that examples of a concept are not only useful as clarification but are good in themselves. For instance, he spends page after page in painful enumeration of cyclic processes in nature. Hundreds of examples are given, one after the other, often whole series of them being simply synonyms.

Everything in this book that is worth saying has been said before, said more clearly and in half the space.

ARTHUR KOHLENBERG
Harvard College Observatory

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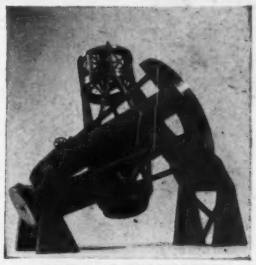

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NOTES ON THE SECONDARY REFLECTION — II

BY ALLYN J. THOMPSON

WHEN it comes to installation and alignment in the telescope, a prism best lends itself to optical centering. This circumstance (apparent from Fig. 3) comes about because the optical and geometric centers of its hypotenuse reflecting surface are coincident at **a**. Thus, exact geometrical centering on the axes of both telescope tube and eyepiece adapter tube is all that is required, save for final correction of the 45° angle. And because of the prism's shape, this can be done with a high degree of precision.

A diagonal, however, if it is to do the same job (furnish an evenly illuminated field that is symmetrical about the axis), must be decentered with respect to each axis, by equal amounts. The amount of offset necessary depends on the angle **u** and the distance **p**, in Fig. 2. It is the distance **ax** multiplied by the sine of 45°, and for our f/4.4 amounts to 0.074"; for the f/8 it amounts to 0.037". In effecting this offset in the two directions, the optical center **a** of the diagonal is made coincident with the point of intersection of mirror and adapter tube axes. Throughout this discussion the axes of both mirror and telescope tube are assumed to be coincident, and intersected in a perpendicular plane by the adapter tube axis.

From a mechanical standpoint, there are several ways of attempting to provide for the radial part of the offset, but the longitudinal offset (lengthwise in the main tube) must be taken care of when making the final adjustments. All these mechanical dodges, however, entail some inconvenience or unnecessary trouble and loss of time, and none of them is foolproof. All of them are dependent in one way or another on accuracy of measurement, and it is most difficult working inside the telescope tube to measure position in either direction to better than about 1/32". Radial measurement is particularly difficult if the tube is not perfectly round. A source of error almost certain to be encountered is that shown in Fig. 5. Here the axis of the spider support, although itself accurately centered or decentered (depending on the method adopted for decentering the diagonal), causes the diagonal holder to be pitched out of parallel to the mirror's axis. The resultant drift of the diagonal's optical center may easily amount to 1/16".

Where such errors exist, and they are practically inevitable, recourse must be had to the several adjustments that in good construction are incorporated in the spider and the diagonal holder. Attempts to make the offset automatically by mechanical means gain nothing except where the offset can be regarded to be of substantial amount, as in a short-focus mirror over six inches in diameter.

It is not our purpose here to describe construction details of adjusting devices for spider and diagonal support; for these the reader is referred to books on telescope making (for example, pp. 116-119 of **Making Your Own Telescope**). Instead, we shall briefly recount how one begins the diagonal adjustment with the assumption that it is centered geometrically, that is, with its geometric center coincident with the intersection of mirror and adapter tube axes.

Optical centering. As we have already mentioned, the correct optically centered position is arrived at theoretically by sliding the diagonal bodily along the 45° inclined plane **dd'** (Fig. 2) until its geometric center has been moved from **a** to **x**. In practice, the diagonal is shifted by successive steps, first away from the adapter tube opening, then toward the mirror, and so on.

Begin by providing a centered peephole at the end of the adapter tube, fixed so the peephole is about 2" beyond the focus of the mirror. Place your eye at the peephole, to see what the reflection appearances tell you about the centering. First you will see the reflected image of the mirror, within which are imaged by two reflections the spider legs and the outline of the diagonal obstruction. Within this latter is seen, thrice reflected, the interior of the adapter tube itself, capped by the peephole.

With the **geometric** centering that should result from careful telescope construction, the imaged diagonal outline is centered in the mirror reflection, but the diagonal itself, circularly outlined, does not symmetrically surround the mirror (Fig. 6). The shift is in the direction of **d** in Fig. 2, as is apparent from the disproportion between the edge separations at **d'** and **d** in Fig. 6. The ratio of these separations will differ widely, depending on the size of the diagonal, the focal ratio of the mirror, the distance **p**, and the axial location of the peephole. In our two telescopes the ratio happens to be, for the f/4.4, about 1:13, and for the f/8, 1:2. The diagonal, too, appears to be eccentrically placed with respect to the lower open end of the adapter tube. (The apparent outline of an elliptical diag-

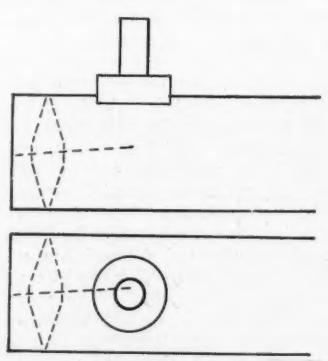

Fig. 5. This diagram shows in two planes of the telescope tube how improper support of an otherwise correctly placed diagonal may cause misalignment of the optical system.

onal is not a true circle, but an ellipse of small eccentricity. In the f/4.4, the eccentricity is not quite 1½ per cent, as seen from the peephole 2″ outside of focus.)

When a position of **optical** centering is attained, there will still remain a lack of symmetry in the relative positions of mirror reflection and the outlined diagonal. But except at low focal ratios it will be so slight as to be beyond detection, and it is this position of apparent equality in the gaps that we should strive for to achieve optical centering. From the near viewpoint in our short-focus f/4.4, however, the ratio of the gaps at **d** and **d′** is 4:5, a considerable change from the 1:13 observed with geometric centering.

For positive determination of optical centering, the peephole should be placed at a deflected position equivalent to that of point **e** in Fig 2, where the converging marginal field rays, prolonged, intersect the optical axis. This position can be calculated, but it is readily found by withdrawing the eye until the mirror reflection has the same size as the diagonal surface. At f/8 this distance will probably be such that an extra adapter tube of

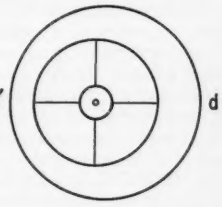

Fig. 6. The appearance of mirror, spider, diagonal, and peephole reflections with geometric centering.

more than the usual length will be required. In our f/8 the point **e** is situated about 5-9/16″ beyond the mirror's focal point.

From this viewpoint, the diagonal outline presents the appearance of a perfect circle. This is not precisely true from any nearer point, as noted at the end of the third paragraph above. The diagonal appears axially symmetric (with proper adjustment) and subtends the same angle as the mirror, hence it and the mirror reflection are concentric and coincident. And since the deflected mirror axis and the adapter tube axis are coincident, the coincident outline of diagonal and mirror reflection appears concentric within the lower end of the adapter tube.

The image of the secondary that is seen in the mirror is displaced from the center (toward **d′**), and thus the image of the axial peephole, centered in the mirror reflection, will not be centered in the diagonal's image. It is unlikely, however, that these displacements can be detected by ordinary means, except where the mirror is of low focal ratio.

Geometric centering. Except in large telescopes, the diagonal may even be left in the geometrically centered position, and with the reflecting angle corrected to 45° the condition for perfect imagery will be satisfied. The only penalty is that the field of full illumination will not be symmetrical about the axis. The displacement of this field in our model telescopes would amount to 0.087″ at f/4.4, and to 0.042″ at f/8 (illustrated to scale in Fig. 7a by the broken circle). A star imaged at **P** then, the most weakened point in the affected side of the originally planned-for field, would have a luminosity of 90.4 per cent in the f/4.4, and of 93⅜ per cent in the f/8. In view of what will be said below, these losses are practically insignificant.

Larger diagonal? Last month it was stated that fitting the value of **v** to the field of a low-power eyepiece does not work out so well. Our concluding discussion here concerns the effect of the dimensional difference between the value

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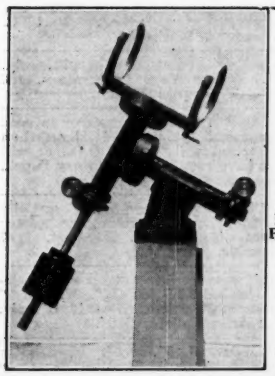

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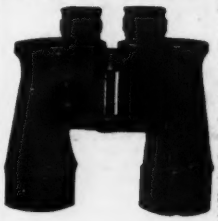

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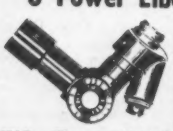

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assumed for **v** in the examples given last month and the greater width of the field of a low-power eyepiece. This problem is closely related to that of geometric versus optical centering.

The outer circle of Fig. 7a represents the field boundary of a standard astronomical eyepiece embracing an area 1" in diameter in the focal plane. The unbroken inner circle shows that portion of the field of view every point in which receives rays from every exposed point on the primary mirror. The diameter and the positioning of this field of full illumination are fixed by the size and positioning in the telescope tube of the secondary mirror. In our case the diameter is ⅝", and the symmetry is the reward for an optically centered diagonal. For any point lying outside this circle, rays from some exposed part of the mirror will miss the diagonal and will be lost to the image. This escape of light is the vignetting effect caused by the dimensional limitations of the secondary mirror surface. Where such vignetting occurs, the curtailed primary mirror area has the shape of a crescent, the apex width of which depends on the star image's distance from the border of the fully illuminated field.

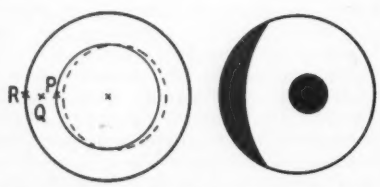

Fig. 7. (a, left) The one-inch field boundary of a standard astronomical eyepiece. (b, right) The non-functioning portions of the f/4.4 mirror at the margin of the one-inch field.

In the absence of an obstructing secondary mirror, a star image would receive light from every point on the primary mirror surface, in which case the image could be regarded as having a luminosity of 100 per cent. But since the exposed or effective area of the primary mirror is equal to its total area minus the obstruction area imposed by the secondary, a star image situated within the ⅝" field of full illumination of our f/4.4 would have a luminosity of 94⅛ per cent, and with the f/8, of 94.9 per cent. In moving the image radially outward from within this field, vignetting sets in, resulting in an accelerating decrease in image luminosity. At the margin, **R**, of the 1" field of the f/4.4, it will be reduced to a mean value of 78 per cent, and to 75.7 per cent in the f/8. The non-functioning portions of our f/4.4 mirror in this circumstance are illustrated to scale in Fig. 7b.

These light losses may appear to be formidably large, but it is unlikely that in the process any dimming of the image could be visually detected. The brightness ratio between two stars one magnitude apart, it should be remembered, is 2.512. Also, the star image in question lies on the perimeter of the field, in a zonal region where eyepiece aberrations render it of little or no account to the observer, granting that he is able to glimpse it in that location. As the image is returned toward the field of full illumination, the losses are found to decrease rapidly; midway between, for example at **Q**, the losses that were suffered at the periphery are diminished by roughly one third. And losses of this small magnitude will be difficult to detect. A star image at point **Q** in the f/4.4 will have

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Much more radical losses were met with in the case of an eyepiece of about 2.3″ focal length made up by the author to give a "rich-field" effect with a 6-inch f/8 telescope. The clear aperture of the field lens was 1.9″, and the field of the eyepiece about two degrees across. The diagonal, 1-7/16″ minor axis, furnished a fully illuminated field of only ¾″ diameter, yet no difference in the brightness of a star image was readily discernible until the image had been moved far out near the perimeter of the field, in a region where the equivalent of a 4¼-inch mirror (about 50 per cent of the 6-inch mirror's area) was all that was being used. Had the secondary been made larger, definition would have suffered as a result of the increased diffraction, with scarcely any visible gain in image brightness in the outlying parts of the field. And as the secondary's image in the exit pupil was only 1.7 millimeters in diameter, the benefit of the eyepiece's wide field could be enjoyed by day as well.

If instead of the diagonals of the table with Fig. 2, others large enough to encompass the whole of the 1″-wide field of view were inserted into the telescopes, then a star image's luminosity would be constant throughout the field. It would be 91¼ per cent in our f/4.4, and 92.1 per cent in our f/8. Referring to Fig. 7b, the cutout crescent portion of the f/4.4 is in this case restored to the mirror's effective area, but the diameter of the centrally obstructed portion is enlarged by 22 per cent, its area by 46 per cent. So that while we have made a probably unnoticeable gain in brightness in the less important outlying parts of the field, we have suffered a likewise unnoticeable loss (of about 3 per cent in our cases) in the critical central parts of the field. But the real damage that cannot be gainsaid is the increased diffraction from the excessively large diagonals (minor axes 1.774″ in the f/4.4, and 1.682″ in the f/8).

In any event, when the eyepiece will not accommodate a wider field than the inner one of Fig. 7a, and this is just about the case for any focal length under one inch, then any argument in favor of a large diagonal becomes irrelevant.

Correction. In the May issue, it was implied that the broken line through **x** in the left-hand portion of Fig. 1, and in Fig. 2, was the minor axis of the indicated elliptical surface. Actually, the broken line referred to the diameter of the cone in that plane, whereas the ellipse, measured perpendicularly to the plane of the paper through **x**, is slightly smaller. The difference is insignificantly small, however, and the cone diameter through that point might well be taken for the minor axis.

SURPLUS GUNSIGHTS

Referring to the article and picture of my Springfield war surplus mounting in the May issue (page 171), I was afraid that it was now too late for anyone interested to buy the same type of gunsight. But I have received word that the American Lens Company, 5694 Northwest Highway, Chicago 30, Ill., has these panoramic gunsights [M12-A-3, marked 4x in Army specifications], at $7.95 postpaid.

FRED P. STROTHER
c/o Boy Scouts of America
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Niagara Falls, N.Y.

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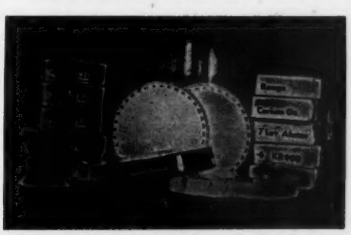
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OBSERVER'S PAGE

Universal time is used unless otherwise noted.

Visual Observing Programs for Amateurs — IV

INSTRUMENTS — (continued)

SMALL REFRACTORS. The first article in this series (April issue, page 147) contained a number of maxims concerning the use of instruments in visual observing. As this installment will illustrate most of these maxims, the reader should again refer to them.

The increase in power between the eye and a 3-inch refractor is dramatic, but a 6-inch telescope, be it refractor or reflector, differs only in degree from a 3-inch refractor. In my own case, I have used refractors of apertures 2.75, 3, 3½, and 4 inches, with focal lengths of 41, 36, 60, and 32 inches, respectively, for periods of from two to 26 years. Careful comparisons made while actually observing have shown that there is little difference in the performances of these four instruments. The following description of my present "workhorse," the last of the above-mentioned telescopes, pictured here, may therefore be considered as representing what can be done with any good 3-inch refractor.

This rather short-focus instrument is on a German-type mounting without circles or slow motions. The mounting is bolted firmly to a circular iron bedplate which rotates on the wooden tripod head. When I am observing the sun or moon or looking at planets, the polar axis is set roughly north and south for easy following of the daily motion of the sky, but for variable star work the equatorial head is swiveled around in azimuth until the telescope is in the most convenient position for looking at the star under study.

The telescope tube can be moved 1½ inches along its cradle for longitudinal balance. As the cross-axis counterweight balances the weight of the telescope, the tripod can be set down on uneven ground and the telescope will be in balance; when I point it at a star it will remain so pointed when I remove my hand. Note that the ensemble is so placed on the tripod that the center of gravity of the telescope and counterweight combined (located at the intersection of the two axes) lies roughly over the middle of the tripod top and not at the north edge as is often found. This simple feature in the design greatly reduces vibration and increases stability on uneven ground.

Both telescope and finder are equipped with dew caps, that on the former being 10 inches long. These are lined internally with green blotting paper. The finder has a 1.6-inch objective, a power of 10 and a field of five degrees. I often use it to estimate variable stars in the 5-8 magnitude range, although binoculars are more convenient for this purpose.

The illustration shows the telescope equipped with an Erfle wide-angle eyepiece two inches in diameter and of 1¼ inches effective focal length. This gives the telescope a power of 25 and a field of three degrees. If the telescope were used only for variable stars of 10.5 magnitude and brighter, I would use the Erfle all the time, but I also use this instrument daily on the sun. For solar work the large eyepiece is unscrewed and a 1¼-inch inside diameter bushing is screwed in place. This bushing will take a solar eyepiece assembly or any standard 1¼-inch outside diameter eyepiece.

In this standard size I have a double achromatic (or symmetrical) eyepiece of 1¼ inches effective focal length which gives 25 power and a field of 1.9 degrees. I actually use this eyepiece much more for variable star work than the wider angle Erfle of the same power, because this procedure eliminates the necessity of screwing the wide-angle eyepiece off and on.

With either of these 25x eyepieces I can see stars of magnitude 10.5, but if I wish to see 12th-magnitude stars, a double achromatic eyepiece of 0.8-inch effective focal length giving a power of 40 and a field of 1.2 degrees is best. Higher powers spread out the light of the night sky so that the sky background appears blacker, and they also spread the stars farther apart. For these two reasons fainter stars can be seen with higher powers up to a certain point. This limit is usually considered to be about 20x per inch of aperture, or 80x with this 4-inch telescope, but in practice the vibration

David W. Rosebrugh's 4-inch f/8 refractor, with case and eyepieces.

THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury enters the evening sky on July 11th, passing the sun in superior conjunction. This elusive planet may be located the last few days of the month, setting nearly an hour after sunset. Look south of the sunset point for a rather bright "star." Mercury will be of magnitude −0.3 on July 30th.

Venus remains a brilliant morning object rising two hours before the sun. The planet moves through Taurus into Gemini in July and is of −3.4 magnitude.

Mars continues its eastward motion in Virgo, passing 1½° north of Spica on July 29th. The ruddy planet has faded to +0.8 magnitude on the 15th, setting 3½ hours after the sun. The disk is only 7″ in diameter, too small for seeing detail except in large instruments.

Jupiter rises from three hours to a little over one hour after sunset through the month, and appears now as a brilliant star of magnitude −2.3. It is moving westward, in apparent retrograde motion, located in Aquarius. Jupiter is the only bright object in that dim region of the sky. The moon is in conjunction twice with Jupiter this month, on the 3-4 and on the 30-31. Elsewhere in this department appears a chart of the configurations of Jupiter's satellites.

Saturn, in Leo, is drawing closer to the sun in the evening sky, and may be observed telescopically for the last time until autumn. The rings are rapidly closing from 3°.9 to 2°.5 inclination. They will appear as a thin band of light on either side of the planet's disk, 38″ across and 2″ wide.

Uranus, in the morning sky, cannot be viewed until August, when the sun will have left its vicinity.

Neptune reaches eastern quadrature with the sun on the 7th and is observable only during evening hours. It remains of the 8th magnitude, and its position is about 3° west of Theta Virginis.

E. O.

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of the telescope in the wind is much less noticeable with 40x than with 80x, so the former is the optimum for faint stars; I use the eyepiece of 40x about 75 per cent of the time.

Why can I see a field three degrees in diameter with the 1¼-inch Erfle but only 1.9 degrees in diameter with the 1¼-inch double achromatic? This is because the field lens of the Erfle is 1.7 inches in diameter while that of the double achromatic is only 1.07 inches, so it intercepts a smaller circle of light. The field of view of an eyepiece is roughly determined by the angle its field lens subtends if seen from a point in the center of the objective lens. Check the above figures and you will find it so, using for the Erfle 1.7 inches seen from a distance of 32 inches—which gives a field of view of three degrees. This design is what makes the Erfle a wide-angle eyepiece.

Why can I see a field of view 1.9 degrees in diameter with the 1¼-inch double achromatic 25x eyepiece and only 1.2 degrees in diameter with the 0.8-inch double achromatic 40x eyepiece? This is because to get the higher power of the 0.8-inch eyepiece it has to be made to only 64 per cent of the scale of the 1¼-inch; its field lens is only 64 per cent of the diameter and it has, therefore, only 64 per cent of the actual field of the 1¼-inch eyepiece, that is, 1.2 degrees. From this we can draw the conclusion that for eyepieces of the same design, in this case the double achromatic type, **power times angle of field equals a constant angle.** In the above cases $25 \times 1.9° = 40 \times 1.2° = 48°$ roughly.

This constant of 48 degrees is the **apparent field of view** of the eyepieces. If I hold one of these eyepieces in front of my eye the bright circle of light I see is 48 degrees in diameter, and is of the same size for either the 1¼-inch or the 0.8-inch eyepiece. In the case of the Erfle eyepiece, $25 \times 3° = 75°$, and this is the apparent field when I hold this particular eyepiece in front of my eye.

This "workhorse" telescope is as useful for sunspot counting as it is for variable star work. For observing the sun, a solar eyepiece assembly is used consisting of one reflection off unsilvered glass (Herschel wedge or hypotenuse of a 90-degree prism), and a Willson goggle dark glass in front of the eyepiece (see page 172, May issue). For the sun, too, the optimum power seems to be 40, so that I use the same eyepiece for sunspot counting as for most of my variable star observing. Lower powers show fewer solar details, whereas with higher powers, at least at 93x and more, heat waves in the atmosphere blur the seeing.

If I use a ¼-inch Huygenian eyepiece giving a power of 128, or a 16-millimeter orthoscopic eyepiece and a 3x Barlow lens giving a power of 152 with this telescope, I can see some of the markings on Mars at opposition. These include the polar cap, Syrtis Major, Trivium Charontis, Utopia and Maria Sirenum, Cimmerium and Acidalium. With a 1/3-inch 96x eyepiece the telescope could probably be used to some purpose on Jupiter, but for serious planetary work telescopes of six inches aperture or more with focal lengths of 48 inches or longer are much more desirable.

After we have discussed 6- to 12-inch reflectors and 6-inch refractors in later articles, I shall make an attempt to compare the merits of small refractors, 6-inch reflectors, and 6-inch refractors, so that anyone who is interested in serious observing can make a well-informed choice of instrument. As the cost and personal labor required to complete a serviceable telescope are of importance in this decision, an attempt will be made to give the out-of-pocket costs and personal time I have spent on each telescope.

I estimate that this small refractor cost me $220 in cash and 150 hours of time, plus 50 hours more spent in making two carrying cases. All equipment was bought secondhand, or at bargain prices. The items bought were objective, cell, tube, rack-and-pinion focusing tailpiece, finder, eyepieces, and prisms for solar, zenith, and erector eyepieces. The items made were tripod, mounting, solar, zenith, and terrestrial prismatic erector assemblies, dust and dew caps; also, there was the general assembly of the whole into a smoothly working ensemble. The two carrying cases were made to enable me to carry the telescope in my car.

DAVID W. ROSEBRUGH
79 Waterville St.
Waterbury 10, Conn.

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evenings, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BOSTON: *Little Planetarium.* Boston Museum of Science, Science Park, Boston 15, Mass. Richmond 2-1410.

SCHEDULE: Tuesday thru Friday at 3:30 p.m.; Saturday, 2:00 and 3:30 p.m.; Sunday, 3 and 4 p.m. Spitz projector. In charge, Charles A. Federer, Jr.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector. For special lectures address Elsworth Jaeger, director of education.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.

SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Director, Roy K. Marshall.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P.O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Curator, Gordon A. Atwater.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

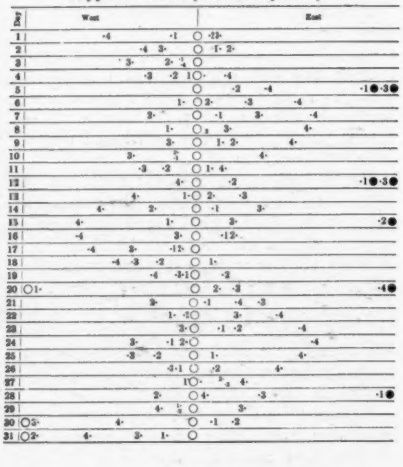
SCHEDULE: Sunday, 4:15 p.m. Special showings on request. Admission free. Spitz projector. Director, Robert E. Cox.

JUPITER'S SATELLITES

Jupiter is now in a favorable position for observations of its four bright satellites. The **American Ephemeris and Nautical Almanac** provides data of two kinds, one in the form of the chart reproduced below. These are the positions of the satellites relative to Jupiter at the Universal time shown, which corresponds to 2:15 a.m. Eastern standard time, 1:15 a.m. Central standard time, and so forth. The motion of each satellite is from the dot to the number designating it. Transits of satellites in front of Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right.

If the chart is studied carefully, the configurations of the moons at other times may be inferred, and estimates made of when to expect transits, eclipses, and occultations. A satellite passes between us and Jupiter when moving from east to west; behind the planet when moving from west to east.

Configurations at 7h 15m for an Inverting Telescope



SATURN'S SATELLITES

I wish to correct my statement in the February issue (page 96) concerning late spring and early summer eclipses of Titan by Saturn. The times of geocentric superior conjunction come earlier and earlier with each revolution of the satellite until now they take place during daylight hours in the United States. To be sure, I realized the shadow of Saturn extends from the sun's direction and that mid-eclipse, occurring at heliocentric superior conjunction of the satellite, would lag more and more behind the geocentric conjunction, but I did not investigate further to find out how great this lag would be. Accordingly, one or two daylight superior conjunctions were tabulated in February, together with the statement that later eclipses would occur in daylight in this country.

Attempts to observe Titan after the eclipses of April 12-13 and April 28-29 revealed no trace of the satellite even as late as 4:00 UT. A check of the synodic period of Titan (15d 23h.3, or 7/10 of an hour shorter than 16 days) indicates that the middle times of all visible spring and summer eclipses are during the evening on the Atlantic seaboard. Observations on May 14-15 and on May 30-31 confirm this; mid-eclipse in the latter case was at about 2h.2.

The first Titan eclipse of July is on the 1-2, at 0h.8, or at about 8:45 daylight time the night the Astronomical League convention opens at Wellesley, Mass. Saturn will still be visible at the two subsequent eclipses on July 17-18 and August 2-3.

PAUL W. STEVENS
2322 Westfall Rd.
Rochester 18, N. Y.

AURORA OVER INDIANA

A spectacular display of northern lights was seen about midnight of May 27-28 from Goshen, Ind. In spite of the bright moon, an auroral glow could be seen extending to the pole star, and white arcs passed into the southern part of the sky.

The display was noticed soon after 11:30 CDT, when a series of bright pulses, about half a second apart, appeared overhead. This rapid effect occurred intermittently for nearly an hour. After a short while, rays appeared in the northwest, lasting from a second to nearly a minute. At 12:15, white draperies were also seen in the northwest, as the display slowly faded.

Although aurorae are not rare at our latitude of 41°, this was the most active display I have ever seen. The aurora was undoubtedly connected with the large sunspot group observed during that week.

OWEN GINGERICH
Goshen, Ind.

VARIABLE STAR MAXIMA

July 1, RV Sagittarii, 7.8, 182133; 8, R Trianguli, 6.3, 023133; 8, X Ophiuchi, 6.9, 183308; 9, R Draconis, 7.6, 163266; 12, T Normae, 7.4, 153654; 17, R Cygni, 7.3, 193449; 19, RU Sagittarii, 7.2, 195142; 20, V Ophiuchi, 7.5, 162112; 21, T Centauri, 6.1, 133633; 23, Omicron Ceti, 3.7, 021403; 27, T Hydrae, 7.7, 085008; 28, X Centauri, 7.8, 114441; 28, V Bootis, 7.9, 142539; 29, S Coronae Borealis, 7.5, 151731. August 2, RS Scorpii, 6.8, 164844.

These predictions of variable star maxima are by Leon Campbell, honorary recorder of the AAVSO. Only stars are included whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

MINIMA OF ALGOL

July 1, 11:33; 4, 8:21; 7, 5:10; 10, 1:59; 12, 22:47; 15, 19:36; 18, 16:24; 21, 13:13; 24, 10:02; 27, 6:50; 30, 3:39. August 2, 0:27; 4, 21:16; 7, 18:04.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See Sky and Telescope, Vol. VII, page 260, August, 1948, for further explanation.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown. Add one hour for daylight time.

METEOR SHOWERS

Two of the finest annual meteor displays occur within three weeks during midsummer, the Delta Aquarids and the Perseids. However, the Delta Aquarids will be hard to observe this year because maximum rates occur on July 28th, one day preceding full moon. The duration of this shower is 12 days, and the expected rate is 20 per hour under favorable conditions. Delta Aquarids are of the slow type and many of them should be bright.

The Perseid meteors begin late in July, and a few of them may be seen after midnight. Their numbers will not rise noticeably, however, until August 7th, and maximum is attained on August 12th, just when the moon is absent. This is a very favorable year in which to organize Perseid meteor observing parties.

E. O.

SUNSPOTS OBSERVED PHOTOGRAPHICALLY

While doing sunspot work at Sacramento College Observatory, I have developed a photographic technique which may be of interest to others. The method has the advantage of eliminating the time and expense of processing a negative, and gives satisfactory results for determining the size and position of dark sunspots.

The observatory has a 12½-inch reflector of 90-inch focal length on which a rack has been mounted to clamp a 5 x 7 camera opposite the eyepiece (focal length 1½ inches). The mirror is stopped down to three inches. The sun's image is pictured by projecting it onto photographic printing paper held in the cut-film holder of the camera.

Even with exposures of 1/100 second there is likely to be some overexposure on a brilliant day if the print is developed in the normal way. However, by **diluting** the developer the printing is controlled without stopping down the mirror to a point where the resolution is impaired. A special grade of lithographer's printing paper, which prints more slowly than ordinary photo printing paper, may be used if necessary. Of course, prints made by this technique are in reverse lighting.

VICTOR W. KILLICK
1857 4th Ave.
Sacramento 18, Calif.

LARGE SUNSPOT GROUP

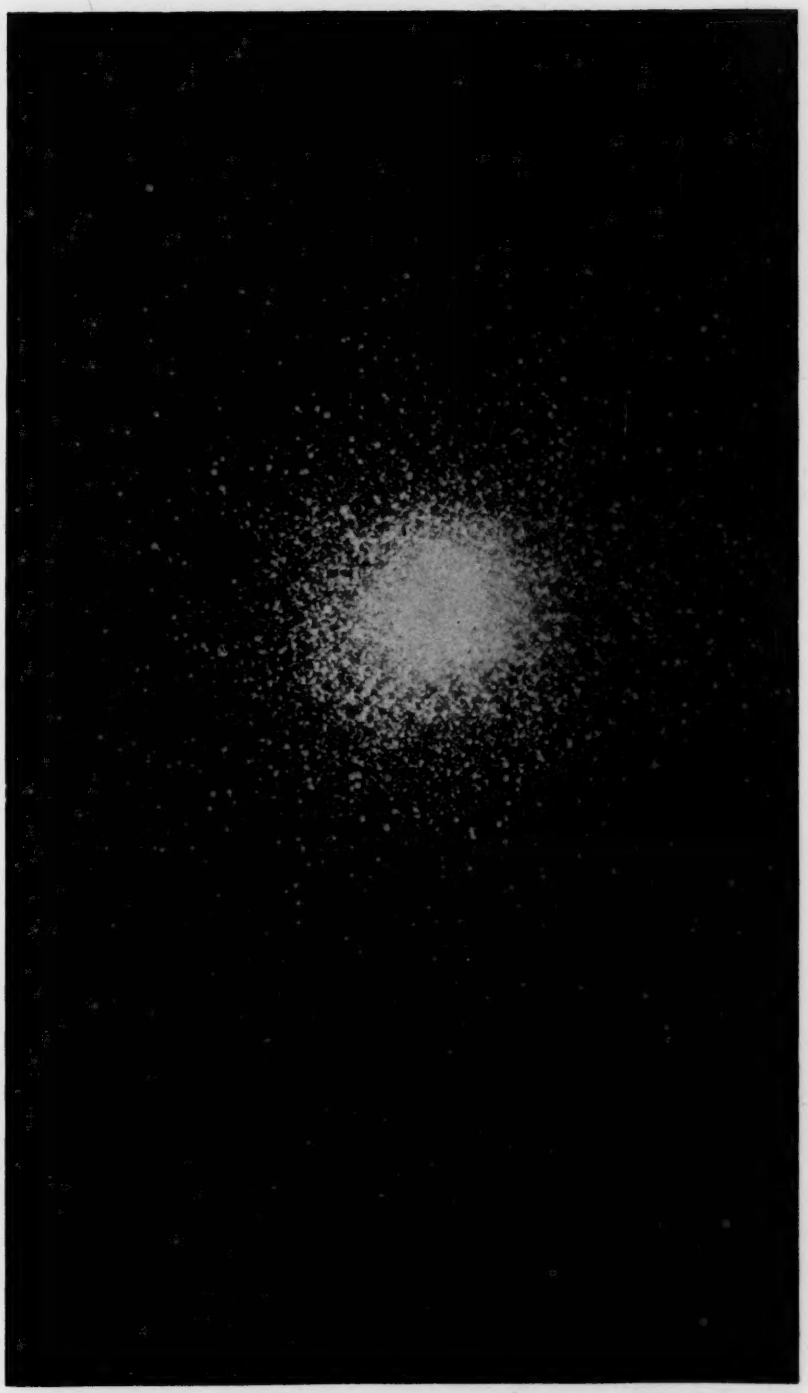
The large sunspot group which crossed the central meridian of the sun during the closing days of May had on the 27th a total length of 191,790 kilometers, as measured by me with a crosshair and stop watch.

HERBERT A. LUFT
42-10 82nd St.
Elmhurst, N.Y.

MOON PHASES AND DISTANCE

Last quarter	July	7,	2:53
New moon	July	15,	5:05
First quarter	July 22,		10:50
Full moon	July 29,		4:17
Last quarter	August	5,	19:56

	July	Distance	Diameter	
Apogee	9d 21h	251,600 miles	29′	31″
Perigee	25d 13h	228,000 miles	32′	34″
	August			
Apogee	6d 15h	251,200 miles	29′	24″



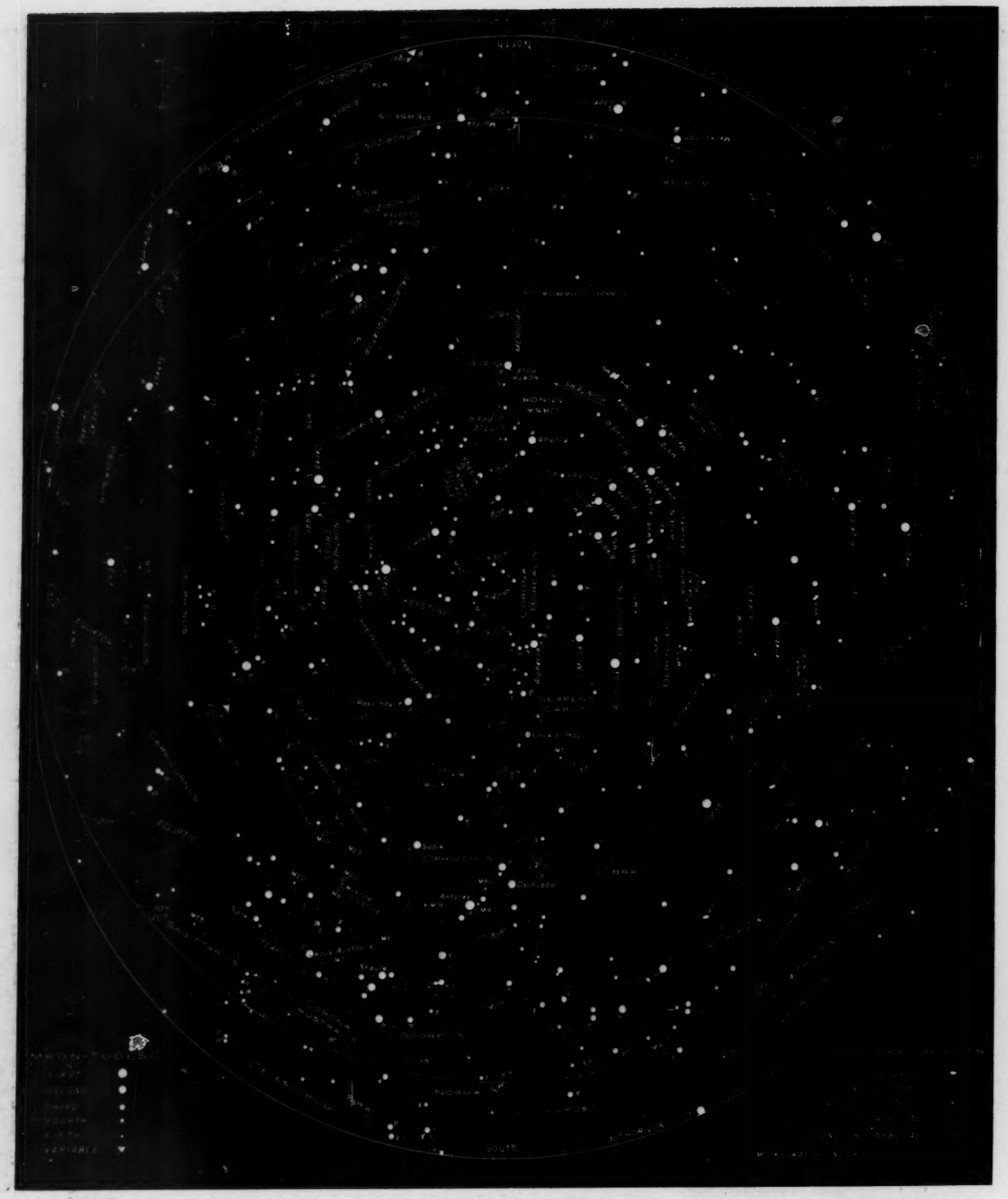
The globular cluster M13, photographed at Mount Wilson Observatory.

DEEP-SKY WONDERS

NGC 6205, M13, 16h 39m.9, +36° 33′ (1950), diameter 23′.2, magnitude photographic 6.78, spectral type dF2. This is the great Hercules globular cluster, rivaling the Orion nebula as the showpiece of the skies, and certainly the outstanding telescopic sight of the northern hemisphere since its accidental discovery by Halley in 1715. Messier, with his 4-foot (long) Newtonian reflector and 60x, could not resolve its individual stars: "Je me suis assuré qu'elle ne contient aucune étoile."

Admiral Smyth assures us that the "slightest optical aid enables us to resolve it," a stretching of the truth that the good admiral occasionally indulged in. Actually, although a trained eye with a 4-inch on an exceptional evening may detect a few stars, for the best views the star lover must use at least a 10-inch telescope. Even then, averted vision will tremendously increase the resolution.

WALTER SCOTT HOUSTON



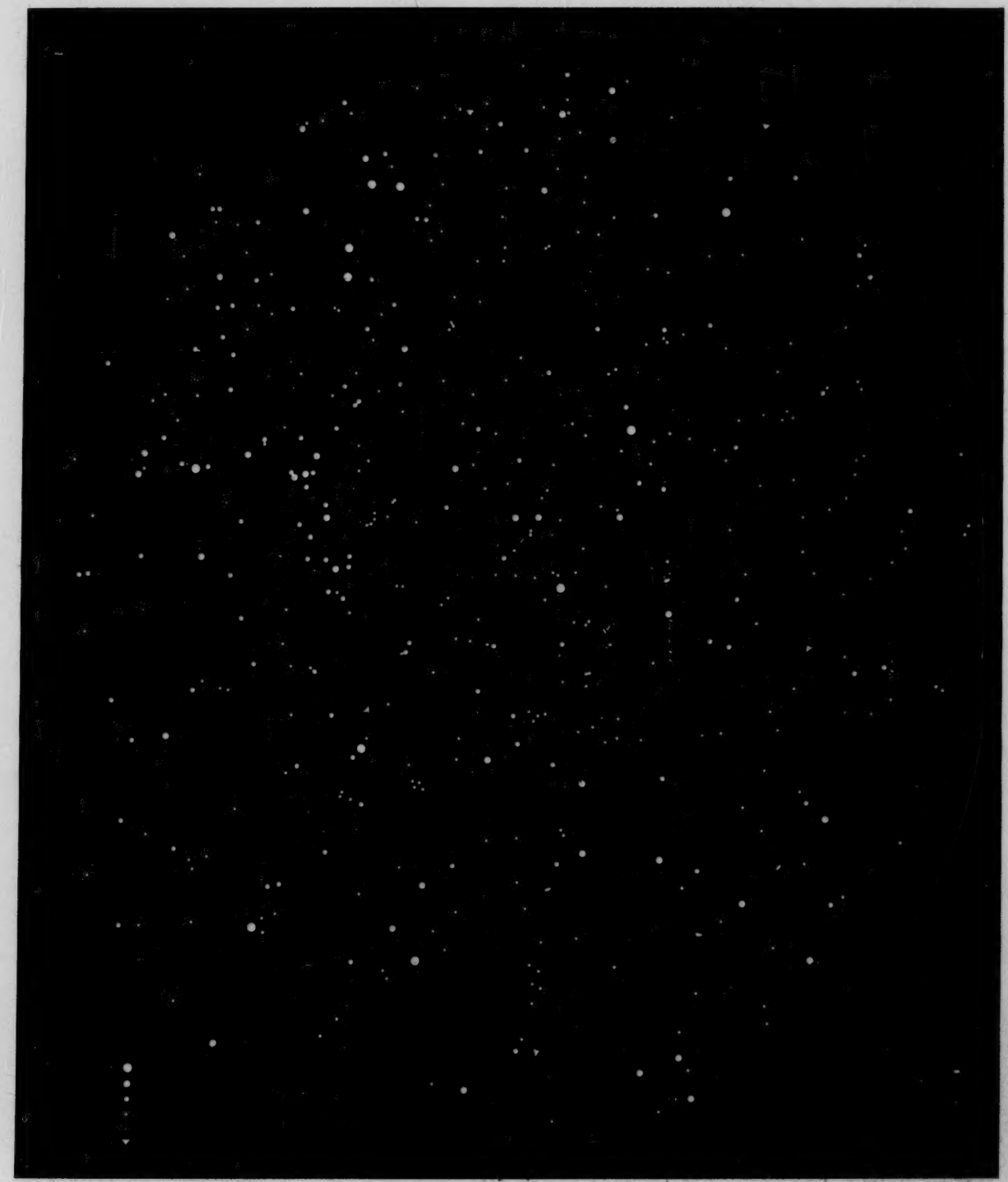
The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of July, respectively.

STARS FOR JULY

LESSONS in stars are nowhere more appreciated than at camp in the summer, and it is unfortunate that late sunsets and daylight saving time restrict the amount of time younger campers can spend under the stars. At many camps astronomy is part of the general nature study program, but at others it is too often neglected. Amateur astronomers vacationing near summer camps might well offer their services in constellation study for both campers and camp leaders.

For a first lesson under the sky it is well not to bring along a telescope, for invariably the interest in the instrument and the desire to look through it detracts from the general attention paid to the sky. But a telescope will serve later to arouse further interest in astronomy and to supplement talks on constellations.

Vega, Deneb, and Altair may be offered as prizes for those looking for the first star in the gathering dusk, and their "summertime" triangle made the starting point for star groups in that region of the sky. The Dipper, Arcturus, Spica, and the Scorpion can complete the simple menu recommended for the first night's bill of stars. The Teapot in Sagittarius is always intriguing, if visible, but not until late does it come well into July skies.



The sky as seen from latitudes 20° to 40° south, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of October, respectively.

SOUTHERN STARS

THERE is no polestar in the southern hemisphere of the sky, but there is nearly everything else. October down under means springtime, and evening skies of great beauty may be seen from South Africa, South America, Australia, and New Zealand.

Looking at the western portions of this sky must be very easy. Arching from the Northern Cross (upside down) in the north to the Southern Cross in the south are the brightest parts of the Milky Way. The constellations Scorpius, Sagittarius, Lupus, and the other smaller groups make a tangle of stars, starclouds, clusters and nebulae that is unequaled elsewhere in the sky.

In the southeast, the Magellanic Clouds may be seen ascending the sky, their "distant association" with the Milky Way apparent almost without the need to know the details of astronomers' studies of these companion galaxies to our own.

In the west part of the sky, Mars will be seen, passing through the Scorpion's head in October, while Jupiter shines brilliantly near the Water Jar of Aquarius. From 30° south latitude, Canopus rises in the southeast as Vega sets in the northwest, and Fomalhaut shines overhead, nearly in the zenith.